A CONTRIBUTION TO THE STUDY OF THE HABITS AND BIONOMICS OF STENOSCELIS HYLASTOIDES (WOLL.), A WOOD-BORING BEETLE PEST OF THE WESTERN CAPE PROVINCE.

A Thesis submitted for the Degree of M.Sc.
to University of Cape Town.

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CONTENTS.

A - INTRODUCTION.

The beetle Stenoscelis hylastoides (Woll.), first described in 1861 is a wood borer of quite considerable economic importance in the Western Cape Province of South Africa.

Because it was not until recently that its effect on house timbers was noticed, it has never before been thoroughly investigated. Apart from the original description (WOLLASTON - 186$\frac{1}{2}$), there is no information in the available literature regarding the habits of the beetle which would have been of practical use in this thesis.

This complete dearth of information therefore necessitated starting from first principles, and deriving technique as the work progressed. This naturally involved much trial-and-error work which took up a lot of the available time.

One of the main reasons for the difficulties encountered in the course of this work, is the fact that not only do both adults and larvae feed and live inside the wood, but the females return into the wood after copulation, to oviposit. This phenomenon is almost unique among woodboring beetles that have been investigated, (though it does occur occasionally in others), so that there was no literature available with which to make comparisons, or from which to obtain useful hints. Another serious handicap is the long life history of the beetle (about 1$\frac{1}{2}$ to 2 years from egg to the emergence of the adult from the wood). As the available time was only 1$\frac{1}{2}$ years, much of the work in this thesis is of necessity incomplete, though long-term experiments are still under way, and may produce significant results at a later date.

The fact that there has been no investigation of the beetle indicates that it was not until quite recently that

2/.....it....

it was considered of any great economic importance. In fact, until 1944, it was classified at the Division of Entomology, Rosebank, as a member of the family Ipidae. However, when it brought itself to the notice of the Division of Entomology by its extensive and repeated attacks on public property, it was considered necessary to get some idea of its Bionomics and general activity, to facilitate its discovery and subsequent eradication, and to provide a means of setting the date of original attack for certain legal purposes.

If for instance, a piece of infested wood is discovered in which the majority of the larvae are of a certain definite size it can be stated with a certain amount of accuracy, how old these larvae are, and therefore how old the infestation is. One is thus able to ascertain whether or not the timber-merchant concerned is responsible for the sale and installation of infested timber.

The work was undertaken at the Rosebank Entomological Station of the Division of Entomology, from where the author had easy access to the infestations in houses in the neighbourhood, and in the Western Province generally. Infested wood for experimental purposes was provided by timber-preserving firms in Cape Town.

The author is aware of the fact that part of the information given in this thesis is of a rather negative character, while some of the conclusions arrived at often show a trend of direction rather than a definite result.

The limitation of time makes it impossible to repeat some of the experiments or to carry out new ones to come to more definite results.

3/.....B. Outline...

B - OUTLINE OF SYSTEMATICS.

i) GENERAL CLASSIFICATION. (After IMMS 1934)

ORDER	Coleoptera.
SUBORDER	Polyphaga.
SUPERFAMILY	Rhyncophora.
FAMILY	Curculionidae.
SUBFAMILY	Cossoninae.
TRIBE	Rhyncolini.
GENUS	Stenoscelis.
SPECIES	hylastoides.

ii) CHARACTERS OF THE SUBFAMILY COSSONINAE. (From Bletchley & Leng - 1916)

Small oblong or elongate, black or brown species having the eyes small, sometimes wanting; beak variable in length, often short and broad; antennae variable, both in insertion and structure, the scape generally reaching to or beyond the eyes; club small, oval, feebly antennulated; elytra long, conjointly rounded at tip concealing the pygidium; first and second ventral segments much longer than third and fourth together; femora unarmed.

iii) CHARACTERS OF THE GENUS STENOSCELIS (Woll.) (From Bletchley & Leng - 1916)

Subcylindrical, robust, very short beak, half the length and somewhat narrower than the head; antennal grooves limited to a short broad cavity just in front of the eyes, scape short, slender, feebly clavate, scarcely half the length of the funicle; club rounded slightly flattened, obscurely antennulated.

iv) DESCRIPTION OF SPECIES. (From Wollaston 1865, Tooke 1949, (supplemented by personal observations).

Length approximately 2.7 to 4.3 mms. Robust, subcylindrical. Black, feebly shining, colour uniform. Rostrum short, square at tip. Antennae about half way down

4/.....rostrum.....

rostrum, 11 jointed (club 3 jointed). Thorax about as wide as long, constricted in front, slightly projecting at sides, densely and finely punctuated.

Elytra cylindrical, scutellum scarcely visible. Side paralell, obtusely rounded at tip; striae broad, coarsely punctuated. Intervals between punctuations regular. Difference between these and thoracic punctuations visible to the naked eye. Elytra cover pygidium. Tarsi with well developed tarsal claws.

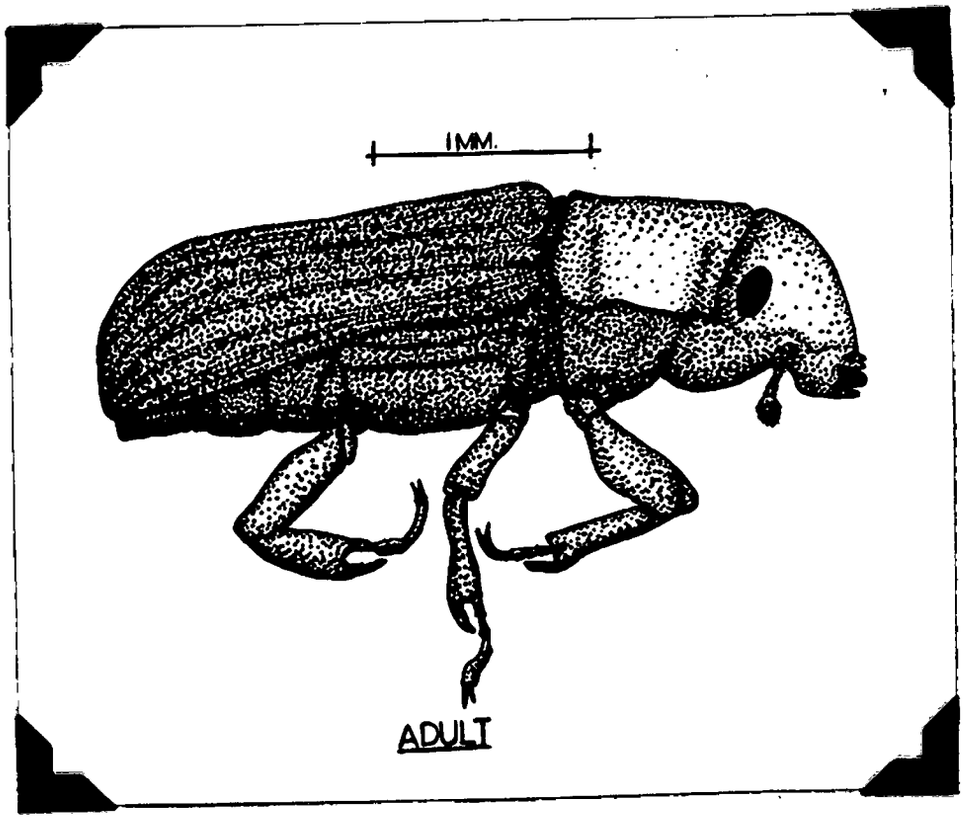

FIG. 1.

C - ECONOMIC IMPORTANCE.

Stenoscelis occurs only in South Africa and St. Helena as far as is known, and it is only in the former place that it is considered of economic importance. Here it has been known as a pest for only 7 or 8 years, and it is only in the Western Cape Province that it is known to have been doing enough damage to warrant any real anxiety. The number of reports of infestation of this beetle have, in the past few years, increased at a sudden and alarming rate.

These reports, sent in to the Rosebank Entomological Station by commercial timber-preserving firms in Cape Town, began to increase rapidly in 1946, and have gone from strength to strength since that time. The following table of reports of Stenoscelis infestations from 1944 to 1951 illustrates this rapid rise.

TABLE NO. 1.

YEAR.	NO. OF REPORTS.
1944	4
1945	6
1946	16
1947	23
1948	44
1949	67
1950	84
1951 (To July)	115.

In the past two years, the number of reports of infestations have been rivalling those of Anobium punctatum (the furniture beetle) and Lyctus brunneus (the Powder-post Beetle), till now considered second and third, respectively, in importance after Hylotrupes bajulus (the so-called Italian Beetle). Stenoscelis shows signs of outstripping them both.

As will be seen in a later section, the damage done by Stenoscelis is mainly to roof and floor timbers, though they may often attack any other part of the house. This damage is very similar to that done by Anobium, and as in the case of Anobium infestation, the cost of replacing badly infested timber and the subsequent treatment with preservatives of the rest of the woodwork in the house, is considerable.

6/.....Apart....

Apart from the Western Province, the one isolated case of Stenoscelis infestation in the Rand Mines, caused the removal and replacement of the timber concerned, with no subsequent infestation.

D - DISTRIBUTION.

i) IN THE WORLD.

The beetle is reported only from South Africa and St. Helena, and Wallace (1895)and Tooke (1949), state that it is indigenous to these areas. Applications to Sir Guy Marshall, expert on Curculionids of the British Museum, indicated that he had no knowledge of Stenoscelis outside of these two areas.

ii) IN SOUTH AFRICA.

Extensive correspondence was entered into with most of the larger Museums and Government Entomological outstations in South Africa, but for the most part, little information was obtained in this way. Apparently, the beetle is unknown as a serious pest outside of the Western Province.

However, a letter from Mr. Tooke, of the Division of Entomology, Pretoria, states definitely that the insect has been fairly frequently taken in Port Elizabeth and George. As has already been mentioned the beetle is very extensively known in the Western Province and has been found as far as Caledon. It is not reported from any place other than the coastal belt, except for one isolated case in one of the Rand Mines, where the infestation has not subsequently been repeated. The wood concerned in this case was, according to Mr. Tooke (who reported the incident) Eucalyptus sp. from Natal. Correspondence with the Chamber of Mines, Johannesburg, indicates that the timber did not, at any time, come into contact with timber from the Western Province, so that it could not have been accidentally infested by proximity to infested timber from the Western Province. This therefore indicates a distribution of Stenoscelis right round the coast from the Western Province to Natal, but not inland.

To have a clearer idea of the distribution between Cape Town and Port Elizabeth, a survey trip was undertaken

8/.....in.....

in February 1951, by car, round the coast as far as Plettenberg Bay. The trip extended through the Knysna forests, and as far inland as Oudsthoorn, with frequent stops along the way. Although timber was inspected all along the route, no indications of Stenoscelis were found. Many samples taken along for the later examination also proved fruitless, though some revealed the presence of Anobium punctatum and certain Bostrichids. The manager of the State Saw Mills at George was later approached with success, but samples of infested wood which he later forwarded to the author, were found to contain Anobium.

The trip was not extended beyond Plettenberg Bay, because the area beyond that falls under the jurisdiction of the Port Elizabeth Government outstation, which had already been approached.

In the Western Province, the distribution is very widespread (See Fig.2). The concentration is heaviest in the southern suburbs, and particularly in the areas Mowbray to Plumstead.

A list of Cape Town suburbs and nearby towns in which Stenoscelis has been found, together with an indication of the time of initial report of infestation, is given on page 9. (All records are from the Div. of Entomology, unless otherwise stated). Towns are indicated in capital letters and suburbs by small letters.

Unfortunately, these records usually indicate infestations that have been under way for a good many years, and therefore cannot be accepted as an indication of the rate or extent of spread of the beetle. However, the earliest records show the beetle to have been already widespread many years ago.

9/.....TABLE NO.2.....

TABLE NO. 2.

TOWN.	YEAR.
STELLENBOSCH	1886 (From S.A. Museum)
CAPE TOWN	" " " "
CALEDON	1919 " " "
WELLINGTON	1922 " " "
Mowbray	1944
Zonnenbloem	"
Bree Rivier	"
Woodstock	"
Salt River	1945
Vasco	"
Rondebosch	"
Green Point	"
Muizenberg	"
Sea Point	"
Newlands	1946
Wynberg	"
Diep Rivier	"
Plumstead	"
Retreat	"
St. James	"
Pinelands	"
Tokai	"
Oranjezicht	"
Claremont	"
Parow	"
Bellville	1947
Tiervlei	"
Hazendal Est.	"
STRAND	"
Rosebank	"
Camp's Bay	"
Vredehoek	1948
SOMERSET WEST	"
HOUT BAY	"
Tamboer's Kloof	"
Clifton	"
Mouille Point	"
Gardens	1949
Goodwood	"
Kenilworth	"
Milnerton	"
Brooklyn	"
Durvanville	"
WAKELEY	"
Observatory	"
Fish Hoek	1950
Simonstown	"
Grassy Park	"
3 Anchor Bay	"
Landsdowne	"
Lakeside	"
GROOT DRAKENSTEIN	"
CONSTANTIA	"
PAARL	"
HERMANUS	"
ROBBEN ISLAND	"

10/.....In.....

In Fig. 1, the shaded area indicates the distribution of the beetle in the Western Province, while those places which have had more than 10 infestations have been marked with a black dot, the names being placed beside ~~it~~them.

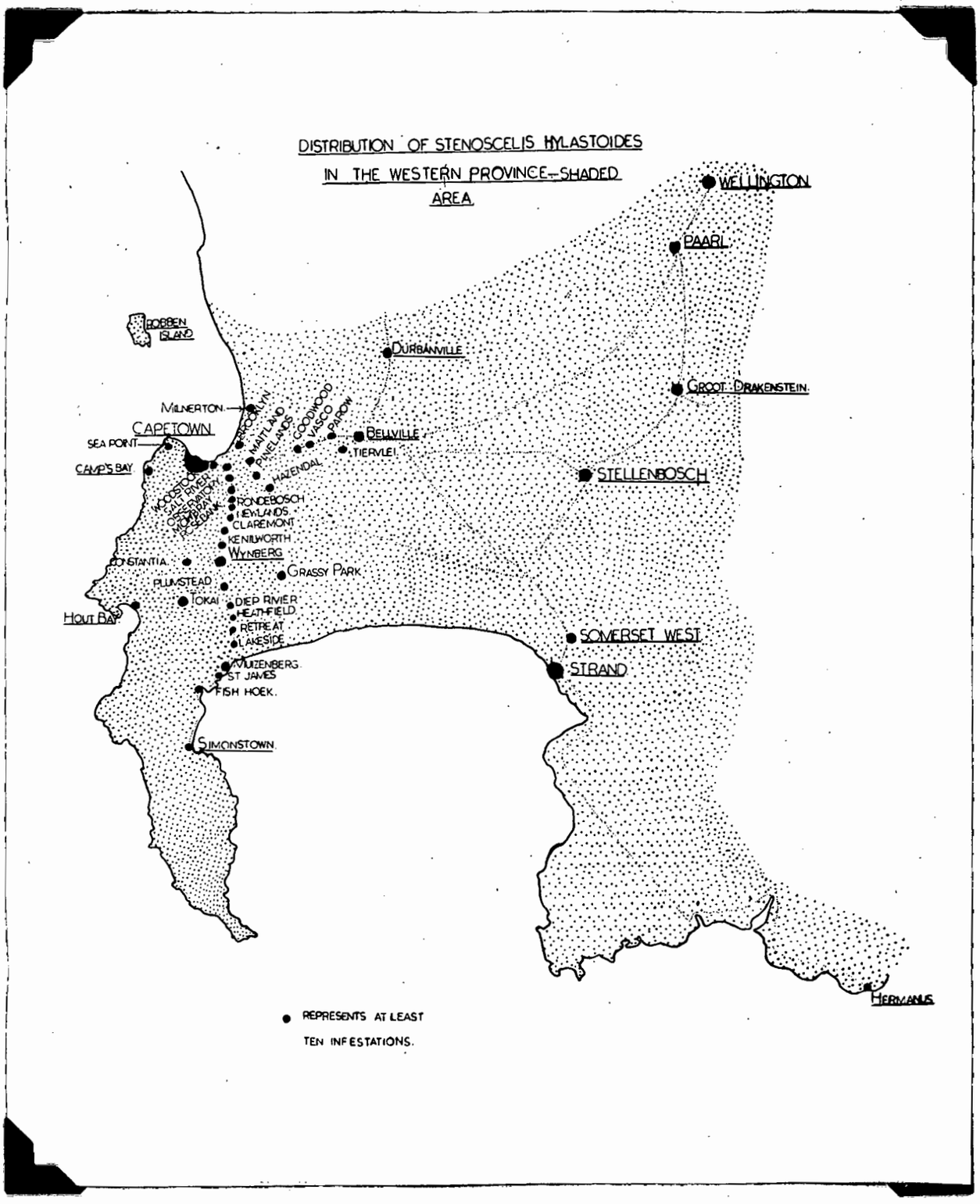

FIG. 2.

E - MATERIALS ATTACKED.

i) SPECIES OF TIMBER ATTACKED.

Stenoscelis attacks a wide variety of types of wood, both hard and soft, with a preference for the softer varieties.

Wollaston (1877) says: "I have taken this insect most abundantly within pieces of dry rotten wood, completely dusty and pulverised, as well as in old decayed posts." Though the present author has observed Stenoscelis hylastoides under these conditions they are certainly not the conditions under which the beetle is most abundantly found, rather to the contrary. The beetles do not attack living wood. In one case where an apple tree was thought to have been killed off by Stenoscelis, it was later dound that the tree had actually been killed by a large Cerambycid borer, with subsequent infestation by Stenoscelis.

The beetle must originally have attacked forest debris, but in the past few years it has begun to enter the new and convenient environment - house timbers.

The houses most frequently attacked are usually between 6 - 20 years old, with a concentration of attack on houses between 11 - 15 years of age. Outside of these limits there are not many reports of attack, one rather unusual one being that of a house which was 105 years of age. (It should be pointed out that the ages of the houses indicate approximately the ages of the timbers used in their construction. Seasoning of timbers today is usually a very rapid process taking usually no more than 3 - 6 months. It was for this reason that wood which was about 12 years old was used for most of the experiments described in later sections).

By comparison it is noted that whereas Anobium punctatum (the furniture beetle) preferably attacks wood that has been well seasoned and in use for a long time (usually about 20 years), and Lyctus brunneus (the powder-post beetle) prefers freshly felled timber (though it also attacks older timbers where the humidity is high), Hylotrupes bajulus (the Italian

Beetle) attacks wood that is 6 - 10 years old. It can be seen that the range of Stenoscelis covers nearly all of these others, and may extend even further (as for instance Wollaston's reference to dry pulverised wood).

The following is a table comparing the species of wood most frequently attacked by the most common woodboring beetles in the Western Cape Province. Extent of damage is marked beside each case.

TABLE NO.3

WOOD	STENOSCELIS	ANOBIUM	LYCTUS	HYLOTRUPES.
A. Hard				
Birch	very heavy	Same	None	None
Beech	Heavy	Same	Same	None
Teak	Little	None	Same	None
Oak	Little	Same	Same	None
Blackwood	Little	Same	Same	None
B. Soft				
Gum	Some	None	Same	None
Mulberry	Little	None	None	None
Apple	Little	None	Same	None
Bamboo	Little	None	None	None
Wattle	Some	None	same	None
Pinus sylvestris	Very Heavy	Same	None	Same
Pinus pinaster	Very Heavy	Same	None	Same
Pinus insignus	Very Heavy	Same	None	Same
Psuedotoxyga toxifolia	Very Heavy	Same	None	Same.

It can be seen from the list that Stenoscelis will attack both soft and hardwoods, with a bias towards the softer varieties. (These records are taken from the files of the Entomology Dept. Rosebank).

By comparison, it is seen that Anobium attacks much the same sort of wood as Stenoscelis, that is, both soft and hard varieties, and both sap- and heart-wood portions. However, it prefers wood older than that attacked by Stenoscelis. Lyctus, on the other hand, confines its attacks to the sapwood of hardwoods, for the most part, and prefers wood much freshly felled than that attacked by Stenoscelis. Hylotrupes confines its attacks to coniferous timbers ex-

clusively.

ii) THE ORIGINAL HOST OF STENOSCELIS.

If the beetle is considered to be indigenous it must necessarily have had an original, indigenous South African host plant. Since it attacks mainly dried timber of 10 - 15 years standing, it is most likely that this original host was the debris of a forest tree. Unfortunately, as has been mentioned, the beetle attacks both soft and hard woods, and though it has a preference for the softer varieties, this does not narrow down the field to be investigated, to any great extent.

It was thought that Yellowwood (the only important indigenous Gymnosperm) might have been the original host, because Stenoscelis shows a distinct liking for pinewoods commonly in use today, and because Yellowwood occurs quite extensively along the coastal area in which Stenoscelis is distributed. However, the beetle has never been reported as infesting Yellowwood; indeed it shows a distinct aversion to it, when blocks of the wood are provided for feeding purposes. The beetle will invariably attack an alternative piece of wood if this is available. This indicates that Yellowwood was probably not the original host.

As Stenoscelis occurs most frequently in the Western Cape Province, it was thought that the host plant might be found here, and some time was spent at the National Botanical Gardens at Kirstenbosch, and on the slopes of Table Mountain, to try to find infestations in situ, since most of the commonest trees of the Western Province are to be found there.

With the help of the Curator of the Kirstenbosch Gardens, the following list of trees was made up, and later inspected for signs of Stenoscelis attack. Unfortunately none was found. The trees mentioned here exist in fair numbers all along the coastal area as far as Natal, and according to the

Curator, are the better known forest trees along this area.

For the most part the extremely hard woods have not been included, while some of the commonest shrubs in the Western Province have been.mentioned.

SPECIFIC NAME.	COMMON NAME.	
Apodytes dimidiata.....	"White Pear."	
Brabeium stellatifolium.....	"Wild Almond"	
Calodendron capense.....	"Wild Chestnut"	
Croton sylvaticus.....	"Croton"	
Cunonia capensis.....	"Red Alder"	
Curtisia faginea.....	"Assegai"	
Ekebergia capensis.....	"Cape Ash"	
Erythrina caffra.....	"Kaffirboom"	
Faurea Macnaughtonii.....	"Beukenhout"	
Ficus capensis.....	"Wild Fig"	(Bostrichids
Gonioma kamassi.....	"Kamassi"	present)
Harpephyllum caffrum.....	"Kaffir Plum"	
Ilex mitis.....	"Without	
Kiggelaria africana.....	"Wild Peach"	
Lachnopylis floribunda.....	"White Alder"	
Leucadendron argenteum.....	"Silver Tree"	(Lyctus
Millettia caffra.....	"Umzimbeet"	present)
Ochna arborea.....	"Cape Plane"	
Ocotea bullata.....	"Stinkwood"	
Olea africana.....	"Wild Olive"	
Olinia cymosa.....	"Hard Pear"	
Platylophus trifoliatus.....	"White Alder"	
Rapanea melanophloeos.....	"Cape Beach"	
Rauwolfia caffra.....	"Wild Quinine Tree"	
Syzygium cordatum.....	"Water Berry"	
Trichelia emetica.....	"Natal Mahogany"	
Virgilia divatricata.....	"Knysna Keurboom"	
Virgilia oroboides.....	"Keurboom"	
Pteroxylon utile.....	"Sneezewood"	
Widdringtonia juniperiodes.....	"Clanwilliam Cedar"	

Shrubs.

Podalyria calyptata.	(Bostrichids present)
Protea emarginata	(Bostrichids and Scolytids)

The insects found in the wood are placed next to the wood concerned.

Unfortunately records are not available as to the type of wood attacked at St. Helena, but the author would like to suggest that when this information does become available, it will provide a clue as to the indigenous host in South Africa.

iii) LOCALITIES OF TIMBER ATTACKED.

Stenoscelis has been most frequently reported from roof timbers, although almost any structural work is liable to be attacked,. The most attacked timbers are tabulated on page 15.

15/.....

IN HOUSES.	EXTERNALLY.
Rafters	Pine Logs.
Beams	Dead Pines (Forest Debris)
Joists	Dead Mulberry.
Strip flooring	Dead Apple.
Parquet Block Flooring	Dead Mimosa.
Doors.	
Door Jambs.	
Door posts.	
Skirtings	
Window Frames.	
Architraves.	
Branderings	
Shingle Battens.	
Picture Rails	
Poles.	
Cupboards. (Built-in)	
Joinery Generally.	

Other commodities attacked(though it is doubtful if they would attack these normally) are Paper, Sawdust, Cork, while the adults will bore easily through a thick layer of bitumen (e.g. the undersides of parquet blocks) to emerge.

16/...THE EGC STAGE....

F - THE EGG STAGE.

The oviposited egg was never observed, but observations of the egg while still within the oviduct were quite frequent.

The reason for this is the habit which the beetles have of boring into the wood imediately after copulation, to oviposit. The eggs, which are no doubt very small, were very probably overlooked in the rough sides or end of the tunnel which the females bore. When it was realised that no other method would reveal the presence of eggs, the author had to resort to dissection of female beetles after fertilisation to see whether eggs were present within the genital organs.

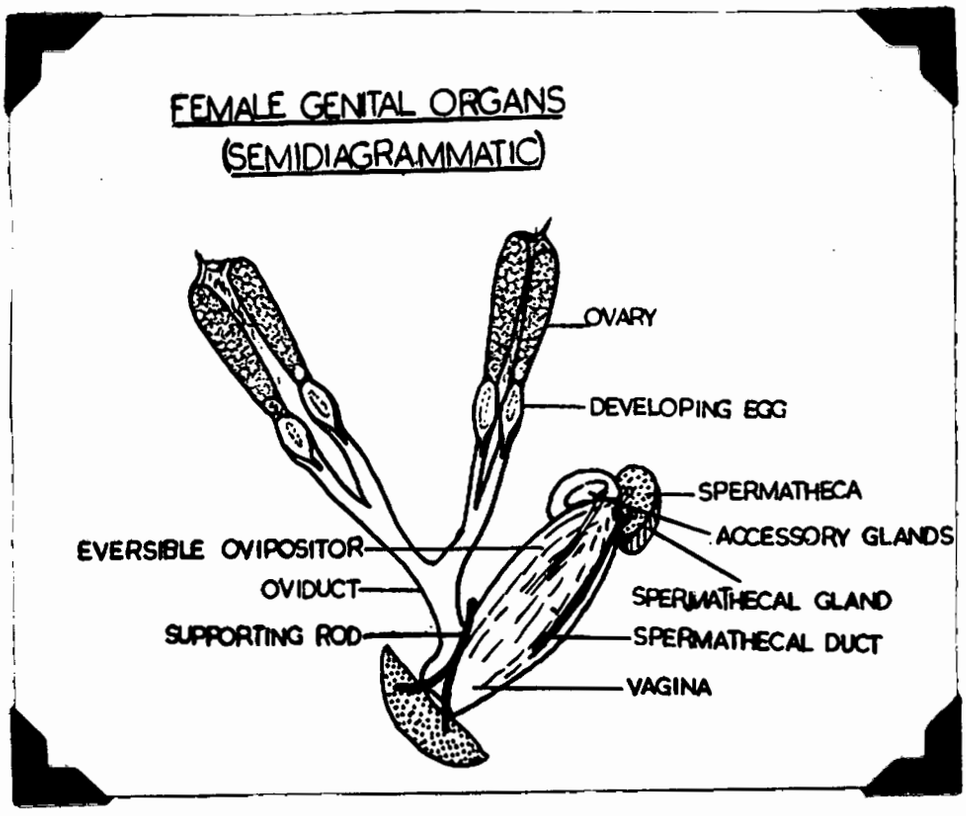

FIG. 3.

The female genital organs are of a common type (See Fig 3), and the eggs were always seen at the tops of the oviducts, usually still attached to the ends of the ovaries.

They were never observed in any other part of the genital organs. From the sizes of these undeveloped eggs it seems that a group of four eggs are laid at one time, with

17/.....another....

another batch following soon after, There is always one large egg at the end of each of the 4 ovaries, with a smaller one immediately behind each of these. The fact that the ovipositor is not chitinised, suggests that the eggs are dropped at the end of the tunnel which the fertilised female bores, rather than being carefully placed in special burrows or grooves in any part of the tunnel. This immediately makes it more difficult to find any oviposited eggs, because also dropped in the tunnel is a lot of frass, which is similar to the supposed size and shape of the eggs.

An attempt was made to find out approximately how long after fertilisation the eggs were laid, by the following method. Fertilised females were removed immediately after copulation to test tubes together with a sterilised piece of the wood from which they were originally taken. They were left alone for a certain period of time, and were then killed by heating and the ovaries were dissected out. The eggs were measured, both length and breadth.

At first some confusion arose because it was noted that eggs of all sizes were present in the oviducts at widely differing periods after fertilisation, but this was explained when females which had been kept separate for up to 8 months, without coming into contact with any other beetles, were also found to contain eggs of varying sizes. What probably occurred is that, in common with many other beetles, Stenoscelis females stored some sperms in the spermatheca, and released these as they were required. The question then arises, as to why eggs of the beetle are not laid all the year round and consequently, why larvae of the smallest observed size (see section G - iv) are not found evenly distributed throughout the year, instead of showing a definite period during which they occur in great numbers. This indicates that they all emerged from the eggs within a certain time, and thus that these eggs must all have been laid within a certain time.

18/.....In....

In the laboratory it was found that one reason for this was the fact that females very probably re-absorb eggs which are ready for oviposition, again in common with a large number of other beetles, when oviposition conditions are not correct. The correct conditions here probably include conditions of temperature and relative humidity normally found in the winter months, or in the period of the year in which the eggs are laid. A possible indication of this occurs in the following table of the sizes of eggs in fertilised females at successive intervals of 1 day, after copulation.

TABLE 4.

NO. OF DAYS AFTER COPULATION.	AVERAGE SIZE OF EGGS IN OVIDUCTS (In mms.).	
	Breadth	Length.
1	.0966	.1010
2	.0986	.1115
3	.0999	.1129
4	.1075	.1132
5	.1096	.1163
6	.1096	.1198
7	.1114	.1225
8	.1173	.1352
9	.1254	.1633
10	.1273	.1974
11	.1270	.2010
12	.1187	.1872
13	.1073	.1352
14	.1004	.1263
15	.0783	.1034

It must be pointed out that each of these readings refers to an individual beetle and the table does therefore not indicate a continuous series. It is noted however, that after about 10 days the eggs appear to grow to their largest size, and then begin to decrease in size. It may be possible that this is due to the eggs being re-absorbed owing to lack of a suitable place for oviposition. In all these experiments, to enable the observer to keep the beetles in view they were given only a thin strip of wood on which to feed, but it was not thick enough to allow them to bore out of sight.

19/....Since...

Since it appears that Stenoscelis lays its eggs inside the wood in a specially constructed tunnel (See section (I.v)), This thin piece of wood is not satisfactory for oviposition, and the eggs are re-absorbed.

The beetles were then allowed to bore as they would normally after copulation, and the tunnels were carefully searched for signs of eggs. None were found. Unfortunately this series of experiments was started too late for any definite results to have been obtained, but the trend here was for the egg sizes to increase continually up to a maximum size (the maximum being after about 3 weeks) and then decreasing very rapidly to a minimum size. The small number of results here does not allow of any conclusions but the experiments are still under way, and will no doubt eventually show relevant results.

THE TIME OF HATCHING.

Obviously the exact time of hatching cannot be found, since no eggs are available, and one must try to deduce this information from comparisons with beetles with similar habits.

In the Bostrichids, the only other family which has been described in sufficient detail to enable one to deduce that its habits are similar to those of Stenoscelis, the eggs are laid at the end of the tunnel which the male helps the female to bore immediately after copulation. This process takes about a week, the eggs hatching about 3 to 4 weeks later.. A very similar condition occurs in the Anobium, but the eggs are laid in pores in the surface of the wood, in this case. (Tooke - 1949 and Munro - 1915). One can only hazard a guess that Stenoscelis behaves in a similar way, and that its eggs hatch about a month after oviposition.

20/.....THE LARVA.

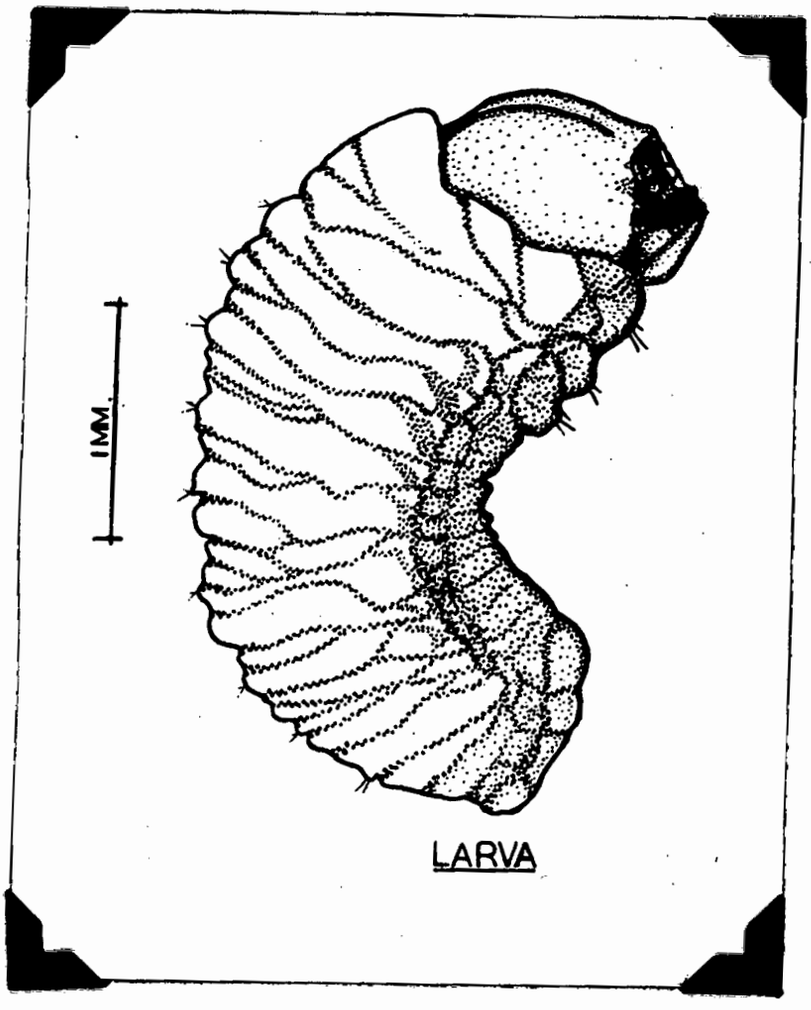

FIG. 4.

Larva.

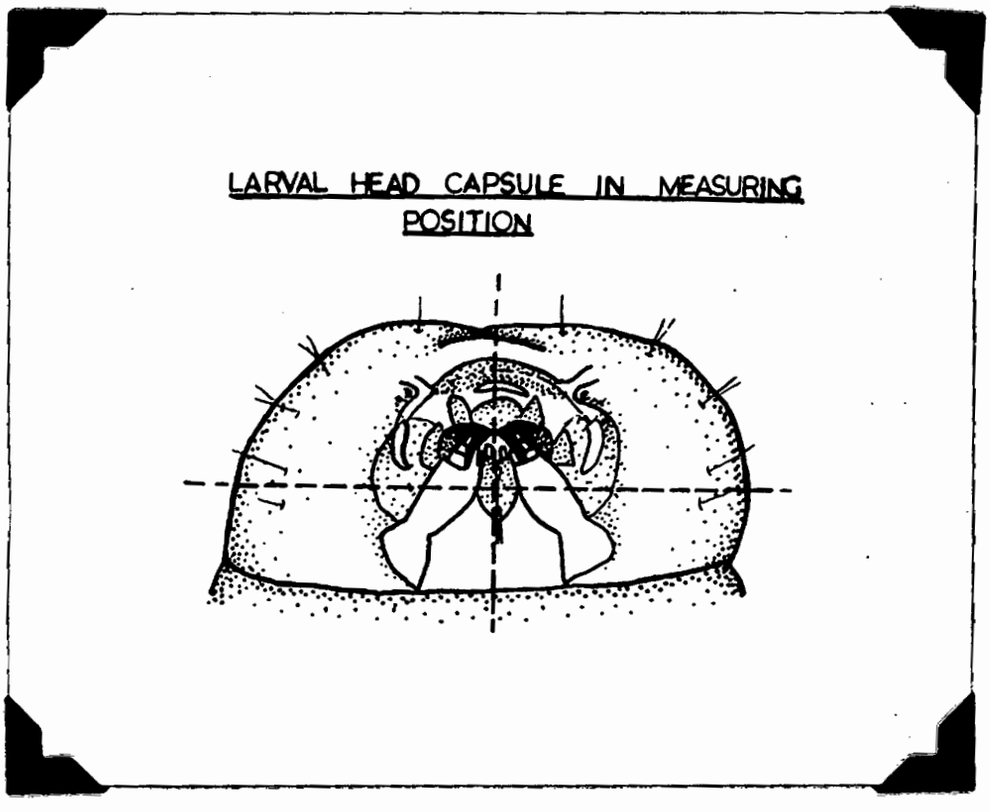

FIG. 6.

Larval Head Capsule in Measuring Position.

G - THE LARVA.

i) DESCRIPTION (ORIGINAL OBSERVATIONS):

Apodous, with slight projections on the thoracic area. Much broader in this area than at the terminal segments. Body has the characteristic Curculionid comma-shape. Head is oval with well-developed, and strongly sclerotised mouth-parts. The rest of the body is white and very much wrinkled. The antennae are reduced to small papillae.

a) Inoculations of Prepared Blocks.

This series of experiments forms the basis of most of the experiments in this section, and a description of the technique is given here.

The blocks were cross-cut sections of the sapwood of Pine or Birch, about 1" square. A hole about ½" deep was made in the springwood portion of an annual ring with a bradawl. When special care in larval observation was needed (as in the case where a larva was about to moult or pupate), the blocks were split open along the annual ring with a single sharp blow of the hammer on a chisel. In these cases the block was then joined together again using transparent tape. The larvae were placed head first into the holes, which were then plugged with pieces of cork. The blocks were set on their sides or upright.

Opening of the blocks was accomplished with a hammer and chisel in the same way as described above, and if the larva had already bored cross-grain, the tunnel was carefully followed by chipping away the wood with a chisel. If the block was not too badly damaged in this process, the larva was returned to it, if it was, the larva was re-inoculated into a fresh block of wood.

b) Under Natural Conditions.

The wood was merely opened with a hammer and chisel. (For more careful work, the chisel was used alone, hand pressure being enough for the chipping).

21/.....The...

The Following Characteristics were noted:-

The larvae prefer the springwood portions of the annual rings and the sapwood in general. They will bore cross-grain, but only to get from one springwood portion to another. If they are inoculated cross-grain, they very often die.

In one case, 25 blocks were inoculated with larvae, across the grain, and another 25 along the grain. Of the former only 6 survived after 2 weeks, and these had begun to bore at right angles to the inoculation hole (i.e. along the grain), while only 2 of the latter 25 had died after the same period of time.

The rate of penetration into the wood varies considerably, but under the most favourable conditions, it has been measured as being half its own length in a day.

As in the adults, the larvae produce much frass consisting of

1) Particles which have not passed through the digestive tract,
2) Particles which have pased through the digestive tract, and have been digested or partly digested.

The former type consists of chewings which have been discarded by the larvae, and feels rough and coarse to the touch, while the latter consists of pellets, cylindrical in shape and with rounded ends. These are much finer, almost dustlike. The percentage of chewings varies with the suitability for digestion, a higher percentage being present when the food is unsuitable.

The frass is usually packed in a little plugs in the tunnel behind the larvae, while the tunnels produced ramify all over the place. Because of the natural curved position of the larval body, the tunnels tend to curve slightly, the gradient of the curve corresponding with the position of the ventral surface.

22/.....If .....

If the larvae are placed on the upper surface of a smooth piece of wood, they are unable to penetrate, and soon die. If the surface is rough, they often do manage to penetrate, though slowly, and many may survive. The reason for this was made clear, when the ordinary inoculating holes were made with a drill instead of an awl. In this case the bottom of the hole was smooth and rounded. The inoculated larvae invariably died after a short time. It appears therefore that the larvae must have leverage points on the sides of the hole or depression against which to press the anterior body segments (which in boring are expanded, probably by the action of body fluids). If the holes are too wide, or if there is no depression, the larvae are not able to penetrate at all.

iii) DURATION OF STAGE.

Much attention was paid to the investigation of the number of larval instars. Because of the difficulty of observing the actual number of instars as shown by moults, due to the fact that the larva lives inside the wood, it was decided to carry out three experiments simultaneously, and to see whether or not the results agreed. These were 1) To try to observe the actual number of moults of inoculated larvae, and noting the times between these moults, 2) to try to calculate the number of instars by means of Dyar's Law, which though not strictly accurate, is sufficiently so to show the number of instars. (Dyar's Law states: "The width of the head capsule of a larva follows a regular geometrical progression in the successive instars") and 3) by plotting a frequency curve of extensive measurements.

Unfortunately, none of these methods is completely accurate, and therefore the results must be regarded as merely indicating the probably trend. As will be seen, 9 or 10 instars are indicated by these methods, within the range of measurements available, and the results agree closely in each method.

23/,,..The....

The experiments are based on the fact that during a larval instar, the size of the head capsule remains constant, changing only after a moult. (Dyar 1890, Przibram 1912 - From Imms - 1934).

Included in the results found in these experiments, was an attempt to determine the rate of growth of the larvae, by utilising the time periods between moults.

These experiments will now be dealt with separately.

1) INOCULATED LARVAL MEASUREMENTS.

Larvae were removed from infested wood by chipping with a chisel and were left in a covered petri-dish for two days to allow any weak or diseased ones to die. They were then divided into three rough groups called A, B, and C. Group C included larvae, the breadth of whose head capsules lay within the range .6875 mms - .9025 mms. Group B within the range .5000 mms - .6874 mms, and Group A within the range 0 mms - .4999 mms.

The groups were picked out because of obvious size differences, at first, and were then fixed within the limits set above, by measurement.

The larvae were measured as follows. An ocular micrometer was used at such a magnification that 8 division = 1 mm. Difficulty was at first encountered in orientating the larva into such a position as to keep it sufficiently still for accurate measurement. Because the larvae have the usual Curculionid curve to their bodies, they could not be laid flat on their dorsal or ventral sides. They could not be killed and then measured, because they had to be observed at regular intervals. The following method was eventually used to keep the larvae in position. A piece of transparent tape, about 2 inches long, was stuck down onto a slide in such a way that the sticky surface was uppermost. The surface was then rubbed gently with a finger to remove most of the stickiness. In measuring the larva was placed lightly near the edge of the tape on its ventral surface. The

24/.....tape.....

tape was sufficiently sticky to hold the larva in that position. If it was very active, it could be more firmly stuck down with no ill effects, and could be easily removed with a still brush and careful handling.

The head of the larva in this position was used for all measurements. The breadth was taken from clear head capsule margin to clear margin. (See Fig.5).

After measurement, the larvae were divided into the three groups A, B and C according to size, and inoculated into blocks of wood as described in Section G (ii). There were usually 20 to 25 larvae in each group, making a total of 60 - 70. Each group of 60 - 70 larvae was then placed, all together, under a known condition of relative humdity and temperature, The former was obtained by using Sulphuric Acid diluted in the proportions prescribed by Wilson (1921), in the bottom of dessicators, and the latter by placing the dessicators in thermostatically controlled rooms. (One at 52°F and one at 84°F).

At first Pinus pinaster was used exclusively for the blocks of wood, but as the supply of this ran out, the author began using Birch. He was aware that the different types of wood might have a considerable effect on the larvae, but when the experiments were set underway, it was noticed that the results obtained did not vary to any great extent. Nevertheless, the results were kept separate for the two kinds of wood.

The blocks were numbered and opened regularly every month, the larval head measurements were taken, and any evidence of moults such as cast skins, was particularly noted. The larvae were also carefully examined for any structural changes, especially after a cast skin had been found, indicating a recent moult. However, throughout the work, no structural changes were observed.

The time of first penetration and the time of death were

25/.....noted...

noted, and from these records, the length of life of the larvae was worked out, under the various conditions of relative humidity and temperature. These results are tabulated below.

TABLE 5.

CONDITIONS OF RELATIVE HUMIDITY & TEMPERATURE.	AVERAGE LENGTH OF LIFE(in days) OF 60 LARVAE.
A. BIRCH.	
i) Room Temperatures and Humidities	112
ii) 52°F " 100% R.H.	180
iii) 84°F " 32% R.H.	103
iv) 84°F " 45% R.H.	85
B. PINUS PINASTER	
i) Room Temperatures and Humidities.	115
ii) " " " 100% R.H.	163
iii) 84°F " 11% R.H.	53
iv) 84°F " 45% R.H.	83
v) 84°F " 90% R.H.	97
vi) 84°F " 100% R.H.	43

(Room Temperatures during the experiment varied between 55° - 65°F and Humidity between 55% - 70% R.H.)

Owing to the inaccuracy of these results necessarily arising out of the rough handling of the larvae, and the fact that the blocks were opened only on certain regular dates, one is not able to draw more than the most obvious conclusions from them. Namely that the adults live longer at the lower temperatures, and have a distinct preference for the intermediate ones, that is those about Room Temperatures (See above). They do not live longer at a higher temperature as is often the case, in fact, the length of life appears to be shortened. At the lower temperatures, a higher humidity makes for a longer life, while at the higher ones, it makes for a shorter life. It is noted that at 84°F and the same relative humidities, the length of life of larvae in Birch and Pinus pinaster is very much the same, and therefore that here the effect of the wood content is probably small.

26/.....A.....

A complete life history including all instars could not possibly be found by using this method because few larvae lived more than about 8 months, due to the necessarily rough handling each month. However, sometimes 2 or 3 consecutive moults were recorded in individual larvae and from these the hypothetical rate of the growth of the larvae was calculated very roughly, as follows:

1a) THE HYPOTHETICAL RATE OF GROWTH OF THE LARVAE.

An attempt was made to correlate the periods between moults so as to have an idea of the length of the total life history of the larva. Unfortunately, these periods are not accurately known, as the inoculated larvae were examined only once a month on regular dates. The periods shown rather represent the maximum periods between moults. Consequently the total period for the larval stage will probably be too long.

When the measurements of larvae that have moulted twice in succession (thus indicating 2 consecutive instars) are arranged in ascending numerical order, the following hypothetical series is obtained:-

TABLE 6.

SIZES OF LARVAL HEAD CAPSULES SOON AFTER SUCCESSIVE MOULTS. (In mms.)	TIME BETWEEN MOULTS. (In days).
1) .3250 - .3626	30
2) .3625 - .4000	30
3) .4000 - .4500	30
4) .4500 - .5000	30
5) .5000 - .5500	60
6) .5500 - .6000	60
7) .6000 - .6725	60
8) .6725 - .7500	60
9) .7500 - .8350	60
10) .8350 - .PUPA.	90
	480

The measurements are all taken from larvae which had moulted under the same conditions of temperature and relative humidity.

27/.....It.....

It must be made clear that this series is not to be taken as accurate since the complete series has not actually been observed in any one larva. The table above consists rather of measurements of consecutive instars in a number of different larvae, which are arranged thus only because they increase in size in what appears to be a regular manner.

The time periods between moults are seen to increase steadily as one approaches the pupal stage.

2) NUMBER OF INSTARS BY CALCULATION. (DYAR'S LAW).

Dyar in 1890 propounded his theory that larval head capsules in insects increased in a regular geometrical progression in the successive instars. This has however, been shown to be not altogether correct, as the theory presupposes that the larvae grow at a constant rate from instar to instar, which is not actually the case in all insects. Thus Dyar's Law cannot be accepted as being altogether accurate, though it finds wide application in determining the number of instars in different types of larvae. For this purpose it is considered to be sufficiently accurate. (Richards - 1949). Though the head capsule sizes calculated by this method are not to be considered accurate, three different methods of determining the number of larval instars are employed and the results so obtained compared with those found by the application of Dyar's Law.

Where, in the previous section measurements of larvae in consecutive instars had been the same in more than 2 cases, these measurements were utilised as follows (IMMS - 1934):-

In each case, the larger size was divided by the smaller, and the average results were taken as the ratio of increase of head capsule breadths between instars. e.g.

28/.....TABLE.....

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In each case, the larger size was divided by the smaller, and the average results were taken as the ratio of increase of head capsule breadths between instars. E.G.

28/.....TABLE..

FIG. 9

NUMBER OF LARVAL INSTARS BY MEASUREMENT OF HEAD CAPSULES SOON AFTER MOULTS

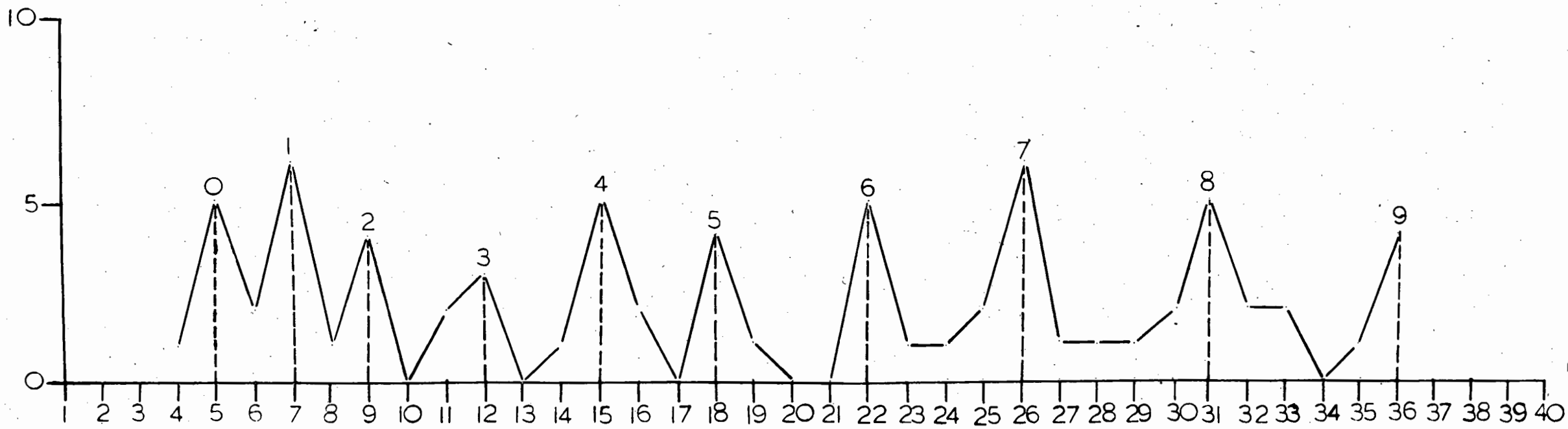


TABLE 7.

INSTAR SIZES USED (In mms.)				RATIO OBTAINED.
.3250	to	.3625	(3 cases)	1.104
.3625	to	.4000	(3 cases)	1.115
.5500	to	.6000	(4 cases)	1.091
.6000	to	.7000	(3 cases)	1.116
.7625	to	.8250	(4 cases)	1.082
			AVERAGE RATIO =	1.110

Then starting with the smallest known instar size, observed during the previous observations in part 1 of this section, one is able to find, by multiplying with the ratio found above the number of larval instars. E.g. (all measurements are in mms.).

TABLE 8.

CALCULATED BREADTHS.

0)		.3250
1)	.3250 x 1.11 =	.3608
2)	.3608 x 1.11 =	.4044
3)	.4044 x 1.11 =	.4444
4)	.4444 x 1.11 =	.4933
5)	.4933 x 1.11 =	.5475
6)	.5473 x 1.11 =	.6075
7)	.6075 x 1.11 =	.6745
8)	.6745 x 1.11 =	.7487
9)	.7487 x 1.11 =	.8300

The number of instars calculated by this method (within the range shown) is about 10. (See table 8, above).

The table is not continued beyond .8300 mms. because this is the measurement of the last larval instar as found in Section H. Note that here and in all further tables and graphs dealing with the number of larval instars, the instar number "0" does not represent the first larval instar, but the first observed instar. There are doubtless 3 or 4 instars before the one numbered "0", between the time of emergence of the larva and the time of its reaching instar no. 0.

Larvae which, during the observations in the first experiments in this section, were known to have moulted fairly recently, by virtue of their not having had time to become properly chitinised, were measured in the usual way,

29/.....and.....

and these measurements were tabulated and plotted in a frequency curve (See FIG.6). The modes of the composite curve thus obtained were taken as representing definite instar sizes, and when tabulated they form a series as in Table 9108. It will be seen that the series agrees closely with table . Here again the number of instars indicated is in the vicinity of 10.

The author is aware that the number of measurements making up this table are not very many, but the peaks which the graph shows are very definite, and are therefore probably representative of the instars ~~they represent.~~

3) NUMBER OF INSTARS BY THE PLOTTING OF A FREQUENCY CURVE OF HEAD CAPSULE MEASUREMENTS.

About 730 larval heads were measured in the usualy way, and a frequency curve was plotted (FIG. 7). Since the head capsule size changes only during a moult, but remains constant during an instar, it was expected that the curve ottained would show a series of modes corresponding to the series of instars.

The following is a table of the group sizes(in mms) corresponding to the group numbers in FIGS. 6 and 7.

30/ .....TABLE.....

TABLE 9.

GROUP NOS.	GROUP LIMITS	GROUP AVERAGES	FREQUENCY FIG. 6.1	FREQUENCY FIG. 7.2.
1	.2626 - .2785	.2692	0	3
2	.2786 - .2945	.2853	0	0
3	.2946 - .3105	.3013	0	3
4	.3106 - .3265	.3173	5	6
5	.3266 - .3425	.3333	1	6
6	.3426 - .3585	.3493	2	11
7	.3586 - .3745	.3653	6	15
8	.3746 - .3905	.3813	1	12
9	.3906 - .4065	.3973	4	22
10	.4066 - .4225	.4133	0	6
11	.4226 - .4385	.4293	2	11
12	.4386 - .4545	.4453	3	22
13	.4546 - .4705	.4613	0	6
14	.4706 - .4865	.4773	1	14
15	.4866 - .5025	.4933	5	27
16	.5026 - .5185	.5093	2	16
17	.5186 - .5345	.5253	0	21
18	.5346 - .5505	.5413	4	31
19	.5506 - .5665	.5573	1	31
20	.5666 - .5825	.5733	0	11
21	.5826 - .5985	.5893	0	12
22	.5986 - .6145	.6053	5	20
23	.6146 - .6305	.6213	1	11
24	.6306 - .6465	.6373	1	27
25	.6466 - .6625	.6533	2	38
26	.6626 - .6785	.6693	6	51
27	.6786 - .6945	.6853	1	22
28	.6946 - .7105	.7013	1	30
29	.7106 - .7265	.7173	1	35
30	.7266 - .7425	.7333	2	51
31	.7426 - .7585	.7493	5	53
32	.7586 - .7745	.7653	2	25
33	.7746 - .7905	.7813	2	12
34	.7906 - .8065	.7973	0	7
35	.8066 - .8225	.8133	1	12
36	.8226 - .8385	.8293	4	34
37	.8386 - .8545	.8453	0	7
38	.8546 - .8705	.8613	0	2
39	.8706 - .8865	.8773	0	4
40	.8866 - .9025	.8933	0	2
		TOTAL =	71	728

The positions of the modes in the graphs are in red in the above table. When these are tabulated alone they take the following form.

TABLE NO. 10.

MODE NO. (INDICATING INSTAR NO.)	A. MEASUREMENT. FIG. 6.1	B. FIG. 7. 2.
0	.3173	-
1	.3653	.3653
2	.3973	.3973
3	.4453	.4453
4	.4933	.4933
5	.5413	.5505
6	.6053	.6053
7	.6693	.6693
8	.7493	.7585
9	.8293	.8293

31/....THE....

In both graphs there are 9 instars indicated between head capsule sizes .3586 mms. and .8385 mms., and in Graph No. 2 an extra instar in the vicinity of .3106 to .3265 mms. is indicated, making a total of a probably 10 instars, within the range shown.

THE SEPARATION OF THE COMPOSITE CURVE (FIG.7) INTO A SERIES OF NORMAL FREQUENCY CURVES.

Though the composite curve shows quite clearly 9 modes, it is obvious that the frequency curves which these modes represent overlap to a greater or lesser extent. The result is that the medians of most of the curves are misplaced, and so one can not have a clear idea of the actual average sizes of each curve and therefore of the instars which the curves represent.

Professor Hales, of the Dept. of Mathematics of the University of Cape Town, was approached with a view to finding some statistical means of separating the composite curve into its component normal frequency curves, so as to find the exact medians of each curve, and thus the exact average measurement for each instar. However, the methods suggested were extremely complicated and involved mathematics which the author could not undertake. As an alternative, the following method, which is not entirely accurate, but which serves to show approximately where the medians of each curve would fall, was used. In effect, what is shown by this work, is that the modes which the author has found in the composite curve, are, for the most part, where they should be, and that no modes which should have been put in, have been left out. The method involves guessing approximately where the median would be as one takes each curve in turn, but according to Prof. Hales, this is not as inaccurate as it appears, because, one can get quite a clear picture of where the median should be, by observing the lie of the points which contribute to the shape of the curve. For the purposes of the work, the end

32/.....slope

A. SUBDIVISION OF THE COMPOSITE CURVE INTO A SERIES OF NORMAL FREQUENCY CURVES. BEGINNING FROM LEFT HAND SIDE.

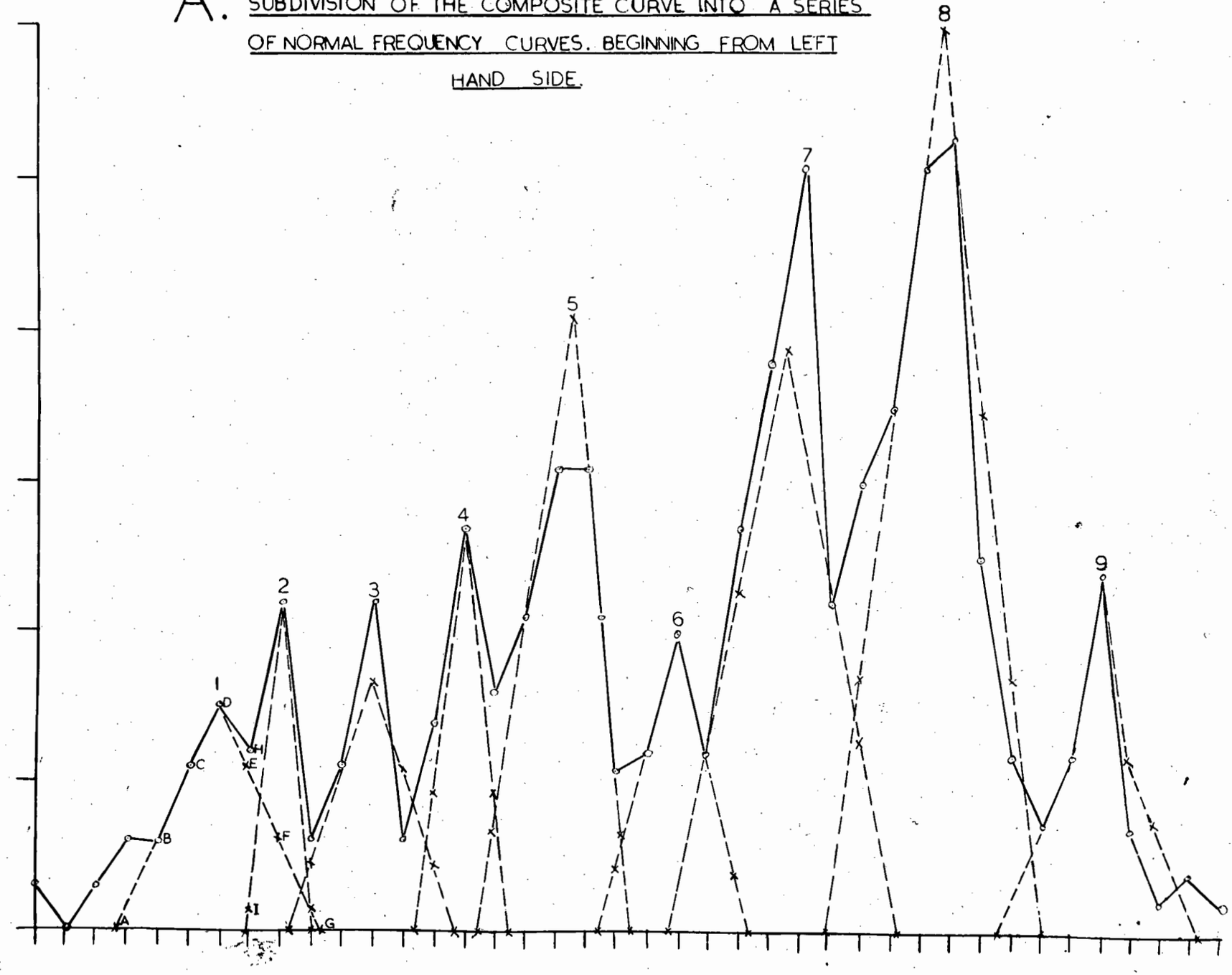
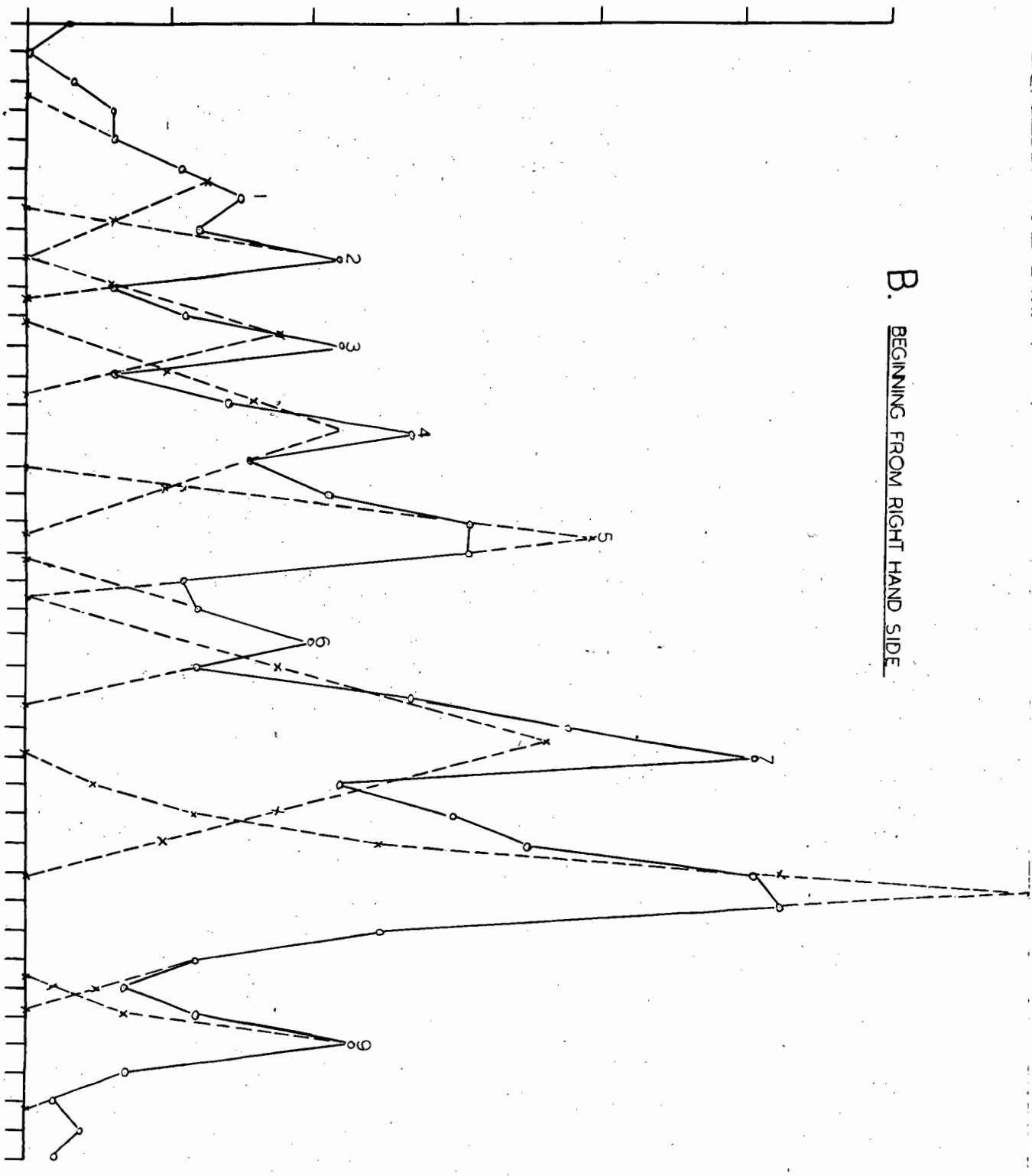


FIG 7A

FIG. 7B.



B. BEGINNING FROM RIGHT HAND SIDE

slope of the last definite curve on one side is considered to be accurate and fixed, and the rest of the separation is worked out on this supposition. Then as a check the end slope of the last definite curve on the other side is considered to be accurate and fixed, and the process is repeated in the opposite direction. This results in the two graphs in FIGS. 7 A and B, where in Graph A, the left hand slope of curve No.1 is considered fixed and in Graph B, the right hand slope of curve No. 9 is considered fixed. These will now be taken separately.

(FIG.7A. The left hand slope of curve No.1 is considered fixed, the points in it being named ABCD. Now because this curve No.1 is to be a normal frequency curve, its mode, point D, is taken as the median, and the points DEFG are plotted symmetrically against points ABCD as the right hand slope of curve No.1.

Quite obviously, curves nos.1 and 2 overlap to some extent, and they must be separated. According to the observed left hand slope of curve no. 2, the point H is a point common to curves 1 and 2 indicating where they overlap. But we have just calculated that actually point E lies on the right hand slope of curve no.1 and not point H. Therefore actually H is not common to the two curves, and does not indicate where they overlap.

However, for this group, the sum of the calculated frequency of measurements E, lying on the right hand slope of curve no. 1, and the frequency which will lie on the left hand slope of curve no.2 should equal the observed frequency H. Therefore if one subtracts E from H one should get the point which lies on the left hand slope of peak nol 2. This point is marked I.

Observed curve no.2 is very definite, and is almost a normal vurve, so the mode is here accepted as being the approximate median, and point I is joined to the top of the

33/.....peak.....

peak. Curve no.2 is now to b a normal curve, so its right hand slope is plotted symmetrically against its left. This process is continued along the graph to the last right hand slope of curve no.9.

For the most part, where the observed curves are already very nearly normal curves, as in peaks 2, 3, 4, 6, and 9 the mode is in each case taken as being the median. However, in curve no.7, the number of plotted points which go to make up its left hand slope are far more than those which go to make up its right hand one, and the mode and median cannot coincide here. In this case an approximate median is chosen, and the calculated curve is plotted around this. In curves nos. 5 and 8, it is clear that the modes actually lie between the points at the tops of the observed curves. The median is here taken as the middle point, and so the calculated mode is higher than the observed mode of those curves.

This point has been confirmed by Professor Hales.

It is seen that for the most part the calculated medians fall along the same groups as the observed.modes.

FIG.7B Here the right hand slope of curve no.9 is considered to be fixed, and the same process as for graph A is repeated this time going from right to left.

In this case curves 7, 3 and 1 are considered to be asymmetrical, and the appropriate medians are chosen for them.

Here again, the calculated medians for the most part fall in the same groups as the observed modes.

To make sure that there had been little mistake in the plotting of the graphs, the approximate areas of 1) the original observed graph (FIG.7) 2) graph A (FIG.7A) and 3) graph B (FIG.7B), were calculated in the following way. The distance between one and the next group on the horizontal axis was taken as being equal to 1, and the number of squares above each of these units was counted, assuming that the mid-vertical line showed an approximate average. For

34/.....the....

the graph in FIG.7, the total area was calculated. For graph A (in FIG.7A) and B (in FIG.7B), the area of each calculated normal curve was worked out separately, and these were then all added together, to give the total area for the calculated graph.

The results were as follows:

TABLE NO. 11.

FIG. NO.	TOTAL AREA. (Sq. mms.).
7	709
7 A	714
7 B	719

Allowing for a certain amount of error, the results are fairly close, and it may be taken that no gross errors were made.

4) COMPARISON OF THE RESULTS OF THE THREE METHODS OF THE NUMBER OF LARVAL INSTARS.

It can be seen that the methods so far employed all indicate 9 instars within the range of measurements approximately .3600 to approximately .8300 mms.

A comparison of TABLES 8 and 10 will indicate the close similarity between all the measurements corresponding to the different instars. As has already been mentioned, these measurements are not accurate, but the fact that there is a similarity between them indicates that the instars that they represent, do in fact exist.

35/.....TABLE.....

TABLE 12.

INSTAR NO.	1) DYAR'S LAW (TABLE 8)	2) OBSERVED MOULTS (TABLE 10A)	3) FREQUENCY CURVE (TABLE 10B)
0	.3250	.3173	-
1	.3608	.3653	.3653
2	.4044	.3973	.3973
3	.4444	.4453	.4453
4	.4933	.4933	.4933
5	.5475	.5413	.5505
6	.6075	.6053	.6053
7	.6745	.6693	.6693
8	.7487	.7493	.7585
9	.8300	.8293	.8293.

In section H (ii), the size approximately .8300 mms., is the constant size of the larva immediately before pupation, and this size is seen, in the above tables, to be very constant also, as the final larval instar.

In tables 8 and 10A the sizes corresponding to instar No. 0 appear. This seems to indicate a possible tenth instar here.

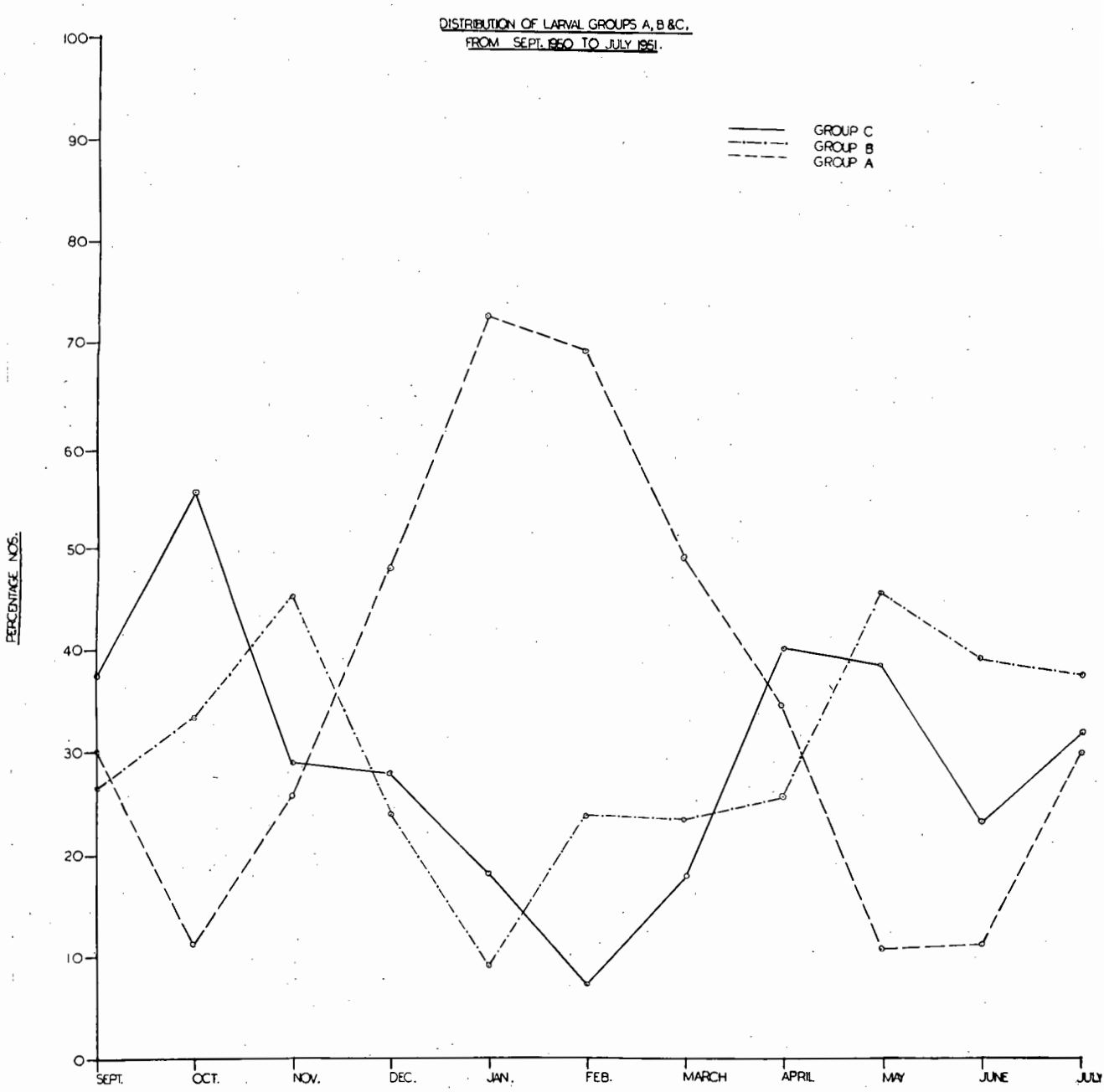
iv) LARVAL SEASONAL HISTORY.

In order to form an idea of the larval seasonal history, a series of head capsule measurements was taken every month, the random larvae used being removed from the wood at intervals of 4 to 5 days. Since the number of larvae taken varies considerably from month to month, the graph drawn shows the percentage of the three groups A, B and C (See section G (iii)) each month.

The following results are obtained.(See graph in FIG.8) The groups were followed from September, 1950 to July 1951. Group A. (Omms. - .4999 mms.) starts in an intermediate position in September, 1950, and drops to a minimum in October. It then rises quite sharply to a maximum in January - February, and drops again gradually during the following months, to rise slightly in June - July to occupy its intermediate position once again.

36/..Group B.

FIG.8


DISTRIBUTION OF LARVAL GROUPS A, B &C,
FROM SEPT. 1950 TO JULY 1951.
GROUP C
GROUP B
GROUP A
PERCENTAGE NOS.
100
90
80
70
60
50
40
30
20
10
0
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MARCH
APRIL
MAY
JUNE
JULY

Group B. (.5000 mms. to .6874 mms.) starts lower than Group C in September, 1950, and generally followw the trend of line C, though it drops to a minimum just before C. It then rises to a maximum in June 1951, where it is considerably higher than C.

Group C. (.6875 mms. to .9625 mms.) Starts in an intermediate position in September, 1950, rises to a maximum in October, 1950, and drops to a minimum in February, 1951. After this it rises gradually again to its intermediate position in July, 1951.

A possible explanation for this sequence of events is as follows:

Group A. Since these larvae are obtained first in size large enough for measurement, during January - February, the graph shows a large peak at this period. The peak would be especially pronounced because it is during the same period that Pupation occurs, removing many larvae belonging to Group C and thus increasing the relative numbers of this group. After this time, the line drops gradually to a low position in May - June, when many of the larvae are growing into size B, and drops to a minimum in October, when, according to the records on pupation times, (Section H) the number of larvae preparing to pupate is at a peak, thus decreasing the relative numbers of Group A. It should also be mentioned that during this time (from August to January) the sizes of the larvae of this Group are probably very small, and are overlooked, again decreasing the numbers of this group.

Group B. Being an intermediate group these should take up an intermediate position. They drop to a minimum just before Group C since many of the larvae of this group are busy changing into those of Group C size. The line then rises sharply, as the numbers of group A become converted into Group B, to a maximum at the time just prior to the time of maximum of Group C. i.e. at a time just before the larvae are preparing to pupate.

37/.....Group C.

Group C. The numbers of Group C increase to a maximum as the time for pupation draws closer (See section H). After this period, the numbers drop sharply, as many of the larvae of this group fall out to become adults, thus decreasing their relative numbers. The numbers rise slowly again to their intermediate position in the following winter.

By utilising the rate of growth (TABLE 6) and again by using the larva of Anobium as a guide, the following seasonal history is deduced. (Always remembering of course, that this plan is very approximate, and only gains some significance by the fact that it agrees in part with the seasonal history deduced by means of the graph above.).

The following is the Rate of Growth table, with the approximate months during which the groups occur fitted in.

TABLE 13.

HYPOTHETICAL INSTAR SIZES. (mms.)	TIME BETWEEN MOULTS (Days)	MONTHS OF THE YEAR
.3250 - .3625	30	October
.3625 - .4000	30	November
.4000 - .4500	30	December
.4500 - .5000	30	January
.5000 - .5500	60	February
.5500 - .6000	60	March - April
.6000 - .6725	60	May - June
.6725 - .7500	60	July - August
.7500 - .8350	60	September - October
.8350 - .Pupa	90	November - January.

From section H, on the Pupa, it is seen that the last larval stage occurs during December - January, and thus the last hypothetical size in the table is assumed to occur during this time, the rest of the instar periods being worked back from it. Taking for granted that all the instar periods found are too long, as described in section G (iii), the time for the occurrence of larvae of the hypothetical smallest size is found to be October of the previous year, and from the Seasonal-history Graph (FIG. 8) it can be seen that larvae of the smallest observed size occur at about the same time.

38/.....If.....

If all this information is now properly arranged, the following probable seasonal history emerges:-

Eggs are hatched in early Spring, and the larvae grow throughout the summer, when they appear in the seasonal history graph as size A; they grow into size B during the following winter, and reach the pre-pupation size, size C, during the early summer of the following year, pupation occuring during the height of the summer, namely from November, to January.

This seasonal history is correlated with that of the adult beetle in section

Some larvae belonging to size group C have actually been observed to pass through the period when pupation normally occurs, without undergoing pupation. They then presumably remain at or near the pupation size until the next summer, when they pupate. During this period of no growth, the larvae are active, and bore extensively. Many such larvae are still under observation, and will no doubt pupate when the time is right.

H - THE PUPA.

i) DESCRIPTION OF PUPA. (Original Observations)

Uniformly white when first formed. Average length (30 specimens), 3.5 mms. Tip of elytra attaining the 4th visible ventral segment of abdomen. Head bent upon thorax. Ultimate and penultimate segments of abdomen ventrally each with a pair of fleshy lateral protuberances. End of abdomen and wing tips apparently covered with a very thin skin. All external features clearly formed on metamorphosis from last larval stage. See FIGS. 9 and 10.

ii) DESCRIPTION OF PUPATION.

Pupae were observed from November, 1950 until February 1951, the greatest number being present in the period November to December, About 40 pupae were observed in all, the majority of these being removed in the usual way from wood brought into the laboratory, the rest being bred from the larval stage in blocks, as described in the previous section. These latter pupae, of which there were six, were all successfully reared through to the adult stage, but none of the former survived more than a week. Apparently the shock of removal from one pupal cell to another artificially prepared one, was too much for them.

The average number of days taken by these 6 pupae, from the day of pupation to the day of adult formation is 22.5. This period is very constant, varying between 21 and 23 days.

Immediately before pupation, the larva looks swollen, opaque and white, and lies quite still in the cell. The average breadth of the head capsules of 20 larvae in this condition was .8300 mms. which by reference to the section on larval instars (Section G (iii) will be seen to agree very closely with the size of the last larval stage as deduced by the various means described there.

The larva remains in this state for about 24 hours, and

40/.....then.....

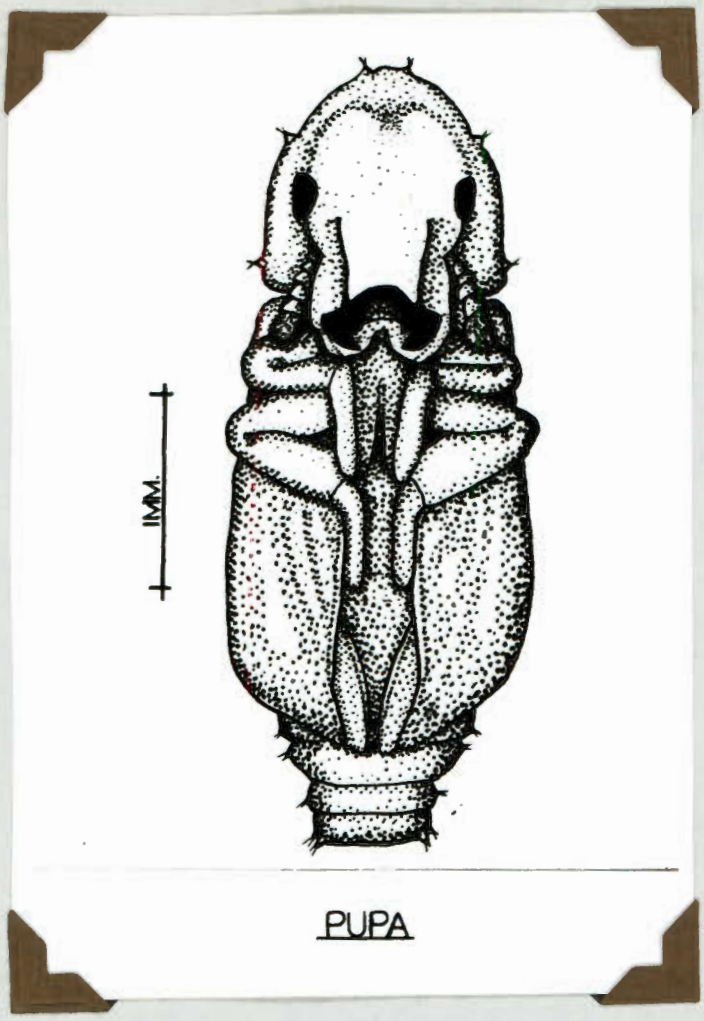


FIG. 9.

Pupa - Drawing.

FIG. 10.

Pupa - Photograph.

(1" = 2mms.)

then begins the process of shedding the last larval skin. This is very much like an ordinary larval moult. The larva straightens out considerably, a dorsal split occurs in the head region, and the larval head capsule slips over the pupal head. The larval skin is then wriggled off towards the terminal segments of the pupa. The larval exuviae generally lies free in the pupal cell, but sometimes remains attached to the terminal segments of the pupa until pupation terminates.

The fully formed pupa lies quite still in the cell except for an occasional wriggle to change position. It lies on its back.

After about 16 days, the first pigmentation of the head capsule begins. This is usually in the region of the mandible tips which go a light orange-brown. The colour spreads over the whole of the mandibles, the rest of the mouth parts and the eyes, and they all gradually darken to a chocolate brown. At the same time, the elytra and legs are becoming coloured light brown too, starting with the tips of the elytra and gradually spreading over the rest of the body surface, until the whole pupa is a uniform light brown, with a darker brown in the regions already described.

At this stage, generally a few hours before the adult is fully formed, the pupa casts off a very thin covering, which enveloped the abdomen and the ends of the elytra, whihh are then free to move round the abdomen, coming to rest in their correct position on the back of the beetle, meeting in the mid-line.

Before this process is altogether finished, the insect is already moving its legs, and immediately afterwards, the adult is able to walk about quite freely. At this stage the tip of the abdomen still projects beyond the end of the elytra, but these terminal segments gradually become inverted into their normal position, until the pygidium fits neatly under the elytral tips.

41/...THE PUPAL CELL

iii) THE PUPAL CELL.

This is not very different from an ordinary larval tunnel, except that it is wider, the end is carefully rounded off, and the walls are particularly smooth. It is usually about 7 mms. long, and the open end is plugged with frass, thus making it more or less airtight. The pupa lies with its abdomen pointing towards the plugged end of the cell. (See FIG. 11.)

FIG. 11.

I - THE ADULT.

i) SEASONAL HISTORY.

Two series of naturally infested blocks were kept in glass jars covered with muslin. One at Room Temperatures (about 55° to 65°F.) and Room humidities (about 45 to 55% R.H), and the other in a thermostatically controlled warm-room set at 84°F, and about 60% relative humidity. The jars were examined every day, and any adults present were recorded and removed.

After 4 months, no adults emerged from the blocks in the warmroom and on opening them they were found to contain only dead beetles. The other jars continued to produce adults.

From the adult emergences from these latter jars the following seasonal history is deduced:-

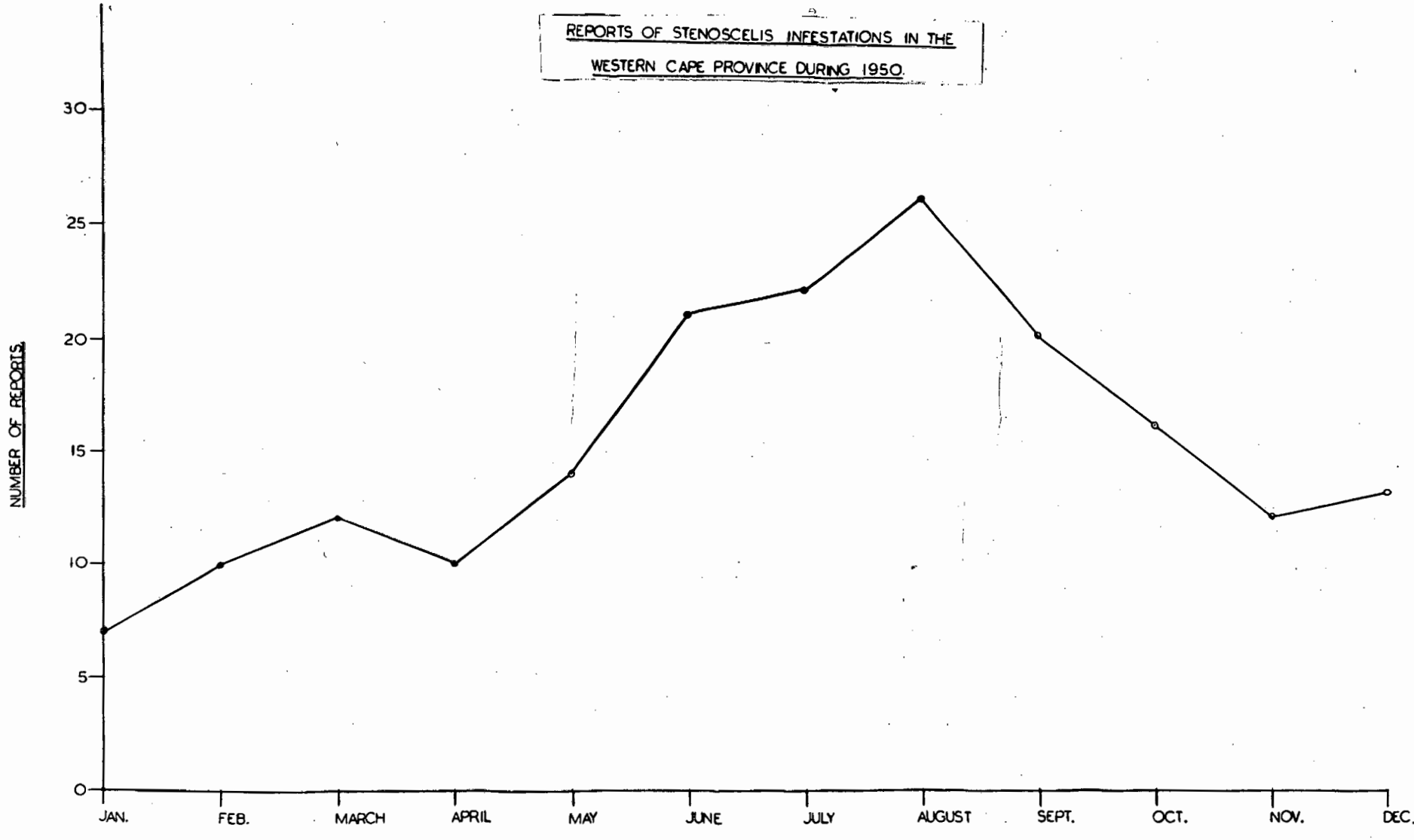
The adults emerge from the wood during the period July to September, copulate and lay eggs. The hatching larvae develop until the following November - December, when they pupate and become adult during January to February. (This has all been described in a previous section). These adults remain in the wood until they are fully pigmented (see below), and then emerge in the following winter as before.

There are a number of facts which support this plan.

1) The number of reports of Stenoscelis infestation reaching the Rosebank Entomological Station take the form of the GRAPH in FIG. when plotted as a frequency curve. There is a definite peak period during the winter months. Since the presence of Stenoscelis is usually noted when the adults are seen moving about, or when wood dust is observed (i.e. when the adults emerge and push the dust out before them), it seems definite that this peak period during the winter must be when the adults emerge. ~~The apparently large number of reports indicated by the graph as being sent in~~

43/....during...

FIG. 12


REPORTS OF STENOSCELIS INFESTATIONS IN THE WESTERN CAPE PROVINCE DURING 1950.
NUMBER OF REPORTS.
0
5
10
15
20
25
30
JAN.
FEB.
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
OCT.
NOV.
DEC.

~~during the winter must be when the adults emerge.~~ The apparently large number of reports indicated by the graph as being sent in during the times of the year other than during the winter, is due to infestations being reported by firms who come across them during investigations. Here the presence of the insect is detected by actually chopping open the wood, rather than by observing adults walking about on the surface, during the emergence.

2) Adults freshly derived from pupae remain in the wood for at least 3 months, and usually 4 or 5, until they are completely sclerotised. If they are removed before this time, they die very quickly. They are not able to bore into wood from the outside as are fully sclerotised ones, but seem to be able to feed and bore quite well if already inside the wood.

As contributory evidence it may be mentioned that at no time were any adults found emerging from the wood which were not completely sclerotised. If adults did emerge at times of the year other than winter (as they very occasionally did), these were also seen to be fully sclerotised.

It seems definite then that an adult is not able to emerge until it is completely sclerotised. Assuming that an insect becomes adult during the period January - February, it has been found that it will take at least until May or June until it is completely sclerotised and therefore able to emerge. (This has been observed in the 6 cases of laboratory bred pupae described in section H, which were allowed to become adult, and were then observed until they emerged from the wood). The emergence time thus correlated with the time of first formation of the adult, agrees well with that deduced by other means, namely from June onwards.

3) The only record of Stenoscelis being taken in flight (K. Barnard, 3000 ft. on Table Mountain - South African Museum) is dated 26/6/1919, and since, in the case of similar

wood-boring beetles, flight is associated with breeding, which in the case of Stenoscelis takes place during the winter months outside of the wood (See section I iv), this indicates that the adults emerge during the winter months.

Evidence to support the idea of copulation and oviposition soon after emergence will be dealt with in later sections, while the seasonal history of the egg, larva, and pupa have already been dealt with.

ii) SEXUAL DIMORPHISM.

Extensive observations were made to try to distinguish the sexes of Stenoscelis. The most important of these was an attempt to use measurement as a sexing aid, the results being represented as a table (No. 14) and graph (FIG. 13.)

A series of beetles were measured by means of an ocular micrometer (1.6 divisions = 1 mm.). Measurements were taken from tip to tip longitudinally, the adult lying on its side. The beetles were then placed in numbered tubes, with some 10% Potassium Hydroxide. After two days they were dissected , and their sex identified, by the presence or absence of the highly chitinised aedeagus of the male. This was continued until the author had measured 210 males and 210 females. (The ovipositor of the female is not chitinised). The following results were obtained:- (Measurements all in mms.)

	Average Length.	Minimum Length	Maximum length.
Male	3.387	2.7	3.82
Female	3.546	2.86	4.30

The following table was constructed from the individual measurements:-

45/....TABLE....

FIG. 13

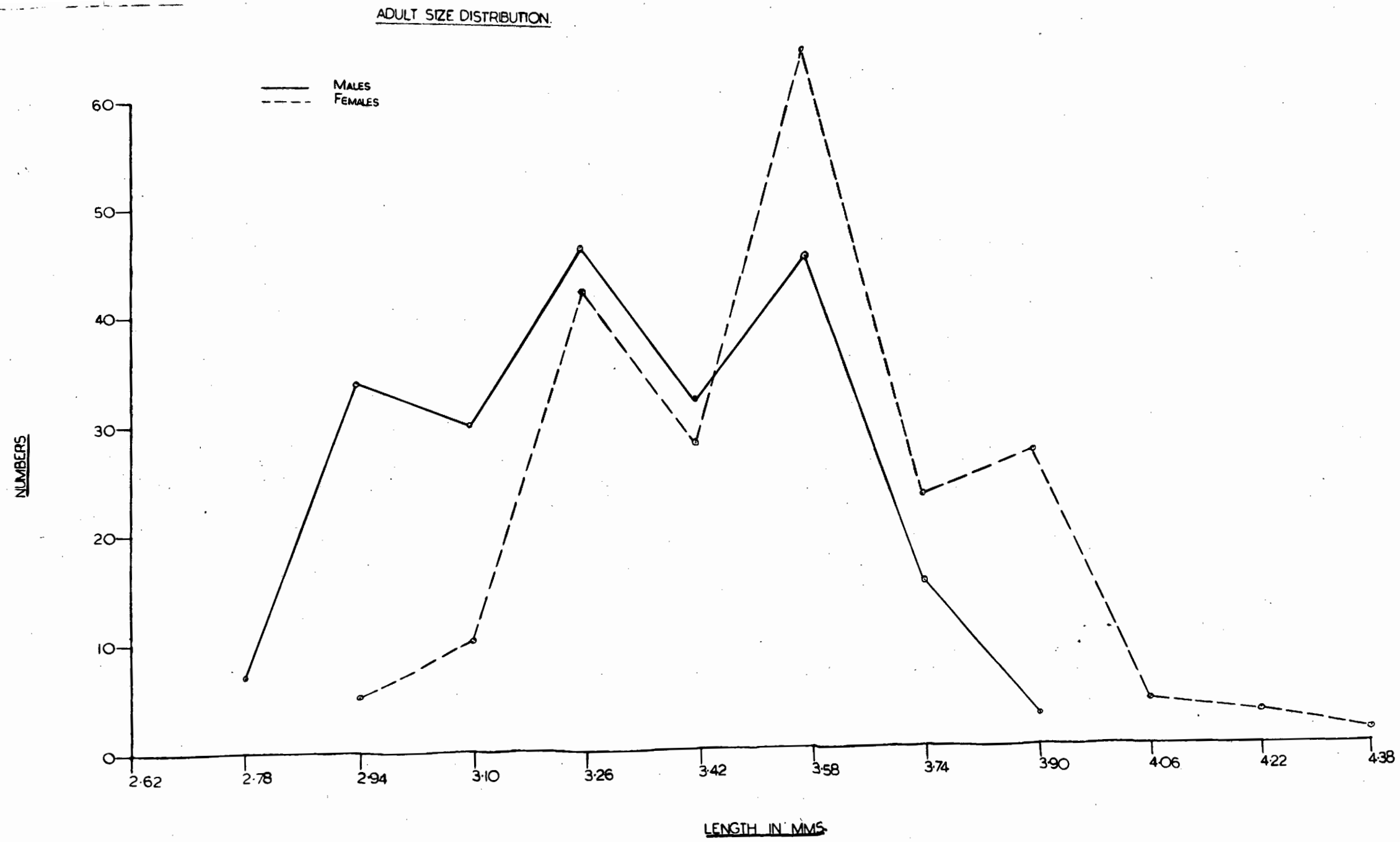

ADULT SIZE DISTRIBUTION.
MALES
FEMALES
NUMBERS
60
50
40
30
20
10
0
2·62
2·78
2·94
3·10
3·26
3·42
3·58
3·74
3·90
4·06
4·22
4·38
LENGTH IN MMS.

TABLE 14.

FREQUENCY DISTRIBUTION OF MEASUREMENTS OF 210 MALES AND 210 FEMALES.

LENGTH (in mms.)	NUMBER OF MALES	NUMBER OF FEMALES.
2.78	7	0
2.94	34	5
3.10	30	10
3.26	46	42
3.42	32	33
3.58	43	62
3.74	15	23
3.90	3	27
4.06	0	4
4.22	0	3
4.38	0	1
	210	210

The above frequency distribution of measurements is graphically represented in the Graph in FIG.13.

From the tables and graph it appears that though the females are on the average slightly larger than the males, this difference in size is not sufficient to provide a means of sexing. Although it may be said in general that a particularly large adult would most probably be a female, and a very small one a male.

The proportion of males to females is about 1 : 2.

In order to find out if there were any known morphological differences, Dr. Hesse of the South African Museum was consulted but he was not able to make any definite statements on the subject. He did, however, suggest some lines of investigation which were subsequently followed up, as follows:-

50 adults were examined with a binocular microscope for any obvious morphological differences. Parts of the body especially examined were a) the terminal segments of the abdomen b) the shape of the abdomen c) the antennae d) sculptures on the elytra and ventral abdomen e) shape of the legs, and the size of the tarsal spurs f) the length of the abdomen g) the length of the rostrum.

iii) EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE LENGTH OF LIFE OF THE ADULTS.

As very few adults freshly derived from the Pupa, were available the actual longevity of Stenoscelis adults could not be found. However, an attempt was made to find out which conditions of temperature and relative humidity were most agreeable to them by seeing under which they lived longest.

Adults kept at room temperatures and Relative Humidities if allowed to bore with being disturbed except for occassional observations, lived for an average (in 43 cases) of 10 months, with the maximum recording of 14 months in one case.

During the period in which the experiment was carried out, the following were the conditions of Relative Humidity and Temperature:

	AVERAGE	RANGE.
Relative Humidity	70%	66 - 75% R.H.
Temperature	60°F	53 - 66°F

Unfortunately the adults were fairly roughly treated during the this time, since the wood was placed regularly against a hot bulb to force them out and occasionally it was opened with a chisel to make sure that the adult was not dead. All this seemed to have an adverse effect on the length of life of the beetles. Adults do not as a rule emerge from the wood of their own accord other than during the breeding season.

In all the conditions used hereafter, the conditions of room temperature and humidity already mentioned acted as the control.

Effect of Temperature and Relative Humidity.

Adults removed from infested wood were kept for 2 days in a petri-dish, to allow any damaged or unhealthy ones to

48/.....die.....

die off. The rest were placed one at a time in tubes with a thick piece of wood (usually a piece of the wood from which it had originally been taken). The tubes were closed with a perforated cork covered with Organdie, and were then placed in dessicators containing H_2SO_4 solution giving relative humidities of 10%, 45%, 75%, 90% and pure water to give and R.H. of 100%.

For observations at lower temperatures, the dessicators were kept in a room with a thermostatically controlled temperature of 52°F. For observations at higher temperatures, the dessicators were kept in incubators adjusted to constant temperatures of 95°F and 100°F, and in a warm-room at a thermostatically controlled temperature of 84°F. In all cases the tubes and wood were examined every two days, because it took approximately that length of time for the relative humidities in the dessicators to re-adjust themselves after the previous opening.

Records were made of when the beetles first began to bore, and their general behaviour during the experiment. Rather than open the wood (in the case of a boring adult) to see if the occupant was still alive, it was brought near an electric light bulb, the heat of thich forced the live beetles to move back along the tunnels.

The object of these experiments was to try to establish which temperature and R.H. was most suitable for the activities of the adult, to facilitate breeding and general activity experiments.

The following results were obtained; (All lengths of life in days).

49/.....TABLE.....

TABLE 15.

TEMPERATURES. Room Temps.	RELATIVE HUMIDITIES. Room R.H.	10%R.H.	45%R.H.	75%R.H.	90%R.H.	100%R.H.
No. Adults		28	30	30	30	35
Length of life	Ø	18.1	27.7	Ø	Ø	Ø
52°F.						
No. Adults	X	X	30	35	30	35
Length of life.			89.5	Ø	Ø	Ø
84°F						
No. Adults.	X	26	37	49	42	40
Length of life		6.7	14.7	28.6	27.5	30.5
95°F.						
No. Adults	20	X	22	55	20	20
Length of life	2		6.9	9.6	7.2	12.-
100°F.						
No. Adults.	X	25	21	25	25	20
Length of Life		1	2	6	4	5.2

Ø = Over 200 days.

X = Condition not used.

Room Temperatures = 53 - 66°F. Room Relative Humidities = 66 - 75%

AVERAGE 60°F AVERAGE 70% R.H.

From the above tables it appears that at the lower conditions of constant temperature and varying humidities, a raise in humidity from 75% to 100% makes little difference to the length of life of the animal. It is at these conditions, and particularly at Room Temperatures that the the animal lives longest, and bores most successfully.

At the higher temperatures, the longevity increases as one approaches 75%, drops slightly at 90% and rises again at 100% R.H. ~~It would appear then that here, longevity is~~

~~longest at 75%, drops slightly at 90% and rises again at 100% R.H.~~ It would appear then that here, longevity is longest at 75% because this is nearest the natural atmospheric R.H., but the author has no adequate explanation for the unusual state of affairs occurring at 90% and 100% R.H.

Consequently, for breeding purposes, the insects were kept at Room Temperatures and a humidity varying between 75% and 100% R.H.

Higher temperatures do not increase their activity, it seems rather to have a detrimental effect.

iv) COPULATION:

Copulation was observed in a petri-dish with filter paper on the bottom, and a smaller dish covering the beetles. Since the sexes could not be told apart, random groups of 40 - 50 adults were introduced into such petri-dishes and their activities watched.

The number of adults in the dish was kept up to the same level throughout the year, and the number of copulations and attempted copulations was noted continually. The following table (No.16) and Graph in FIG. 15 show the frequency distribtuion of copulations and attempted copulations during the period March, 1950 to October, 1951.

TABLE 16.

MONTH	COPULATIONS	ATTEMPTED COPULATIONS
1950		
March	0	3
April	0	0
May	5	6
June	12	10
July	15	12
August	23	17
Sept.	16	20
Oct.	9	7
Nov.	3	5
Dec.	0	3
1951.		
Jan.	0	0
Feb.	0	1
March	0	4
April	3	3
May	7	3
June	10	10
July	20	17
August	25	18
Sept.	18	15
Oct.	6	4

It can be seen that there is a definite season during which copulation occurs, namely the winter months, and particularly towards the end of the winter. There are attempts at copulations right throughout the year, but these are never carried through to completion.

The following activities in regard to copulation were noted:-

On encountering a female, the male begins the courting, by touching her with nis antennae. The forelegs are used for stroking the body of the female. They are used rapidly and alternately, the antennae vibrating rapidly all the while. The male gradually moves round to the hind end, stroking the female all the while, until he is facing in the same direction as she. The female meanwhile stands quite still with antennae folded. The male now begins to stroke the elytra with his forelegs, and then moves up onto the female's back, bringing the second pair of legs into play. While the forelegs are still stroking the dorsal side, the second pair of legs begin to stroke the end of the abdomen, in the vicinity of the female genital opening, to incite extrusion of the vagina. The male genital organ has usually been extruded and is in the vicinity of the female genital opening some time before the vagina is finally extruded to meet it. During the copulation, the male continues to stroke the female as before, with occasional quiescent periods. The female remains quite still during the whole process.

Under normal conditions, the beetles do probably not copulate more than once at a time, since they both immediately begin boring into the wood, as soon as the copulation is over. These beetles have not been observed to emerge from the wood again, unless the food content is exhausted, and they emerge to seek further food.

About 30 copulations were observed as described above. These observations were made almost exclusively between 11 a.m. and 2 p.m., though there were one or two cases earlier in the morning, and a couple later in the afternoon. Night

52/....observations

observations over a period of one month during the winter of 1950, at intervals of 2 or 3 days, showed no copulations occurring at night,

The duration of the act of copulation was fairly constant. The duration was timed from the moment of meeting of the aedeagus and vagina, until the moment of separation. While the temperatures at which the copulations occured were more or less constant, the R.Hs. varied considerably. E.g. where 11 copulations were recorded.....

TABLE 17.

Duration of Copulation. (in mms.)	Temp. during Copulation (^{o}F)	% R.H. during Copulations.
10	67	69
9	59	73
7	63	74
7	66	46
7	66	70
7	66	78
6	69	49
6	59	73
5	65	68
5	62	89
5	66	74
Av. 6.7	65	68

From the position of copulating couples, it appears that the action normally occurs out of the wood. This conclusion is based on the fact that at no time were tunnels found in which the diameter was large enough to accomodate two beetles in copulating position.

Since the emergence season (July to September) coincides with the period during which copulations are exclusively observed, it seems that the adults emerge to copulate.

52/....OVIPOSITION.....

v) OVIPOSITION.

Owing to the fact that the females bore into the wood almost immediately after copulation, the act of oviposition was not observed. However, the following experiments were conducted to try to ascertain where and when the beetles do oviposit.

i) Observation of Fertilised Females.

Females were removed immediately after copulation and placed in glass tubes together with a block of wood. After about two days the females began boring into the wood. Another two days were allowed to elapse, and on each successive day thereafter, one block of the series was opened, until the entire series had been examined. 20 females were observed in this way, the experiment thus taking 24 days in all.

The blocks were carefully examined for signs of eggs, both inside and out. No eggs were ever observed.

The experiment was repeated, with the beetles inoculated into specially prepared tunnels immediately after fertilisation. Again no eggs were observed, probably having been overlooked in the frass and rough sides of the tunnels.

ii) Attempts at Forced Laying.

In an attempt to fforce females to lay eggs in accessible spots they were placed, immediately after fertilisation, in clean glass tubes. It was hoped that they would oviposit on the bottom of the tube, for want of something better. However, lack of food killed the females after a few days. When these females were dissected, fairly large eggs were found in the ovaries, but, as has been described in the section on the Egg, these eggs were probably being reabsorbed, owing to the absence of a suitable ovipositing spot.

The experiment was repeated, using paper on the bottom of the tube, first white, then black, but no eggs were ever observed externally.

54/....iii).....

iii) The Gauze Block Experiment.

Blocks of the softwood portions of Pinus pinaster were cut, about 1½ x 1" x 1" in size. Bandage material or very coarse net was wrapped round them, and stuck down with a thin paste made of flour and water. The blocks were then dried in the sun. Care was taken to see that there was no wood exposed anywhere. The blocks were then placed in deep glass dishes, together with 40 - 50 adults each. Two days after the experiment was begun, and every day after that, the adults were carefully brushed off the blocks, which were then examined with a binocular microscope for signs of eggs laid in the mesh of the gauze. Rather than lay eggs in the mesh however, the beetles merely bored straight through the gauze and into the wood.

The experiment had been used with great success in observations on Anobium punctatum, which however, is known to lay its eggs in pores in the surface of the wood, and so is easily induced to lay in the mesh (SPILLER - 1948). This is a further indication that Stenoscelis may lay its eggs inside the wood.

By comparison, it may be mentioned that Lyctus, which lays its eggs in pores on the surface of the wood as does Anobium, oviposits 2 to 3 days after copulation. So does Anobium. Since Stenoscelis first bores into the wood before it oviposits, as is shown in the previous experiments, and as this process usually takes about two weeks, the time it takes for a normally boring beetle to get reasonably far into the wood, it is assumed that Stenoscelis takes at least 2 weeks before ovipositing and probably longer. (This is assuming that the beetle lays its eggs at the end of the tunnel and not along the sides). In the Bostrichidae, the only other family (for which a description of sorts is available) which feeds on the wood in both adult and larval stages, the time between copulation and oviposition is not known accurately, but as the eggs are laid at the ends of

55/.....tunnels.....

tunnels which the females bore after copulation, the time taken between copulation and oviposition is calculated as being about 2 - 3 weeks, which is the time a normal boring adult takes to bore a tunnel of equal depth.

iv) Long Term Observations.

About 30 adults were placed in a dish with a large block of the softwood portion of Pinus pinaster, which had previously been carefully examined for signs of earlier infestation. The dish was then placed in a dessicator at 100% R.H. and Room Temperatures (about 60 - 70°F) during the experiment. These conditions from reference to the adult longevity tables (Section I (iii)) are seen to be some of the most favourable for the beetles. The dessicator was then set aside for 6 months. After this time the block was carefully opened with a chisel, and the adults removed. The tunnels were carefully examined.

Two small larvae of head capsule sizes (breadth)= .325mms. were discoverd.

The blocks were inoculated on the 21/7/50, and opened on the 16/1/51. Unfortunately, because the pre-oviposition period is not known, the age of the larva cannot be determined by this means. However, it does seem significant that the larva fits correctly into the group A in the Seasonal History Graph in FIG. at the correct time of the year for the presence of larvae of this size.

The impression gained from this work is that oviposition occurs inside the wood possibly about a month after fertilisation. The eggs are probably dropped at the end of the tunnel which the female beetle bores after fertilisation.

56/...ADULT FEEDING.

vi) ADULT FEEDING.

Stenoscelis adults feed and bore in exactly the same way as their larvae.

In feeding, the beetle holds its mandibles apart, and pointing stiffly downwards, and then pushes them strongly downwards into the wood. Here they are pulled together, the head is drawn away, and a piece of wood is drawn into the buccal cavity at the same time. The antennae are held at right angles to the head right throughout the process.

During feeding the beetle rests on its tarsal spurs, digging them into the wood on the sides of the tunnels.

The metatarsi are held up and away from the wood. This method is probably used by the beetles during boring, the tarsal claws probably being used to push them forward.

Attampts to inoculate adults in the same way as larvae proved adequate but unnecessary, since adults are able to bore into wood from the outside without assistance, if the conditions are favourable. These conditions include, a fairly rough surface, since if the wood is completely smooth or polished, the beetles seem unable to bore in, and die. This may account for the small number of Stenoscelis attacks on polished furniture.

On being given a block containing both soft and hard wood, the beetle invariably begins boring at the soft part, but it will attack the hard part if nothing else is available. A striking case is the log shown in FIG.16, which consisted of soft wood surrounding a very hard core. The beetles had riddled the soft wood until it was nothing but a shell, and then began to attack the hard core, for want of something better on which to feed.

A beetle will begin boring almost immediately after being placed on a piece of wood, and always bores along the annual rings. The tunnels may ramify all over the sapwood portion of one annual ring, until it is more or less completely eaten away. Only then will the adult bore cross-

57/.....grain.....

FIG. 16.

grain into the next sapwood ring. There is no definite pattern to the tunnelling, with beetles often recrossing their own paths in their borings.

The damage done by Stenoscelis is very similar to that of Anobium punctatum and Lyctus brunneus with which it is often confused. Its smaller channels and the finer texture of the dust and pellets enable it to be distinguished, by careful examination, from the other two. However, this difference is so slight, that it is not at all apparent to a layman, which results in many reports of Stenoscelis infestation being revealed as Anobium and vice versa.

The beetles leave frass behind them in the tunnels, and may push it out behind them at the entrance holes, to form a small pile of dust at the surface. It is this pile of dust which identifies the presence of the woodborer to the householder.

The frass of the adult is very similar to that left by the larvae, and it is often very difficult to tell them apart. However, it has been shown that pellets are formed by the adults as well as the larvae, and therefore that they do also actually feed on the wood, and do not merely bore through it.

59/...NATURAL ENEMIES...

K - NATURAL ENEMIES.

Two species of Braconid wasps were found to be primary parasites of the pupae and larvae of Stenoscelis. The larvae, pupae and adults of these were collected, but have not yet been identified.

The adults of these wasps were found in great abundance in some of the infestations brought into the laboratory, particularly in Beech flooring blocks during the summer of 1950 - 1951. The larvae were found in only two cases to be actually attacking a larva or pupa of Stenoscelis, but larvae and pupae were very often found lying about in the tunnels. The adults apparently enter down one of the flight holes made by an emerging beetle, and move down it until they find a pupa or larva on which to lay their eggs. The host is sucked quite dry.

The mite Pediculoides ventricosus is found in considerable numbers attacking both pupae and adults, as well as larvae of Stenoscelis, often right inside the wood, throughout the whole of the time that this work was undertaken. These pests are very prevalent in the laboratory, attacking the eggs, larvae, pupae and adults of all the insects under observation in the laboratory.

However, neither of these occur in sufficient numbers to cause any serious damage to the beetles, at present, though it is possible that if necessary these pests can be bred up in sufficient quantities to be of practical use in the biological control of Stenoscelis.

60/.....DISCUSSION.....

L - DISCUSSION.

The state of incompleteness of this thesis is due, to a large extent, to the necessity of deriving techniques for the various experiments as the work progressed. The hard medium in which the beetle lives makes it difficult to observe it in any of the more ordinary ways, resulting in the necessity for less reliable methods of deduction. The lack of time was a serious handicap, since it did not allow any repetition of faulty or indefinite experiments, which might have given more relevant results.

However, the following number of points presented themselves for discussion.

1) The fact that so little published information on this species is available makes it difficult to obtain a clear picture of its distribution, and it leaves the position of its original habitat rather doubtful.

If, as some authors suggest, Stenoscelis is indigenous to South Africa, it must be of reasonably long standing, and must have been well established in an indigenous host plant before the introduction of foreign forest trees. Unfortunately, the beetle has transferred its attentions to these foreign trees, and it is difficult to trace it back to its original indigenous host.

It may even be possible that the beetle has been introduced into South Africa in quite recent times, and is actually indigenous to some other locality where it is so insignificant as to have been overlooked. For example, it may be indigenous to the Scandanavian countries, whence come most of the Pinus sp. forming a large part of the Forests in the Western Province, for which Stenoscelis has a particular liking. Or, as it has been found in Acacia sp., it may have been introduced from Australia.

A study of the chemical compositions of the wood of the

61/.....various....

various kinds of indigenous forest trees, and a comparison with those of foreign trees for which Stenoscelis shows a liking, should provide a clue as to the original host of the beetle.

A further clue might be afforded by information as to which trees on St. Helena are attacked by the beetle, and in what kind of wood it was first found. (The description by Wollaston (1864) and his later (1877) few paragraphs on the habits of the beetle, do not provide any such information).

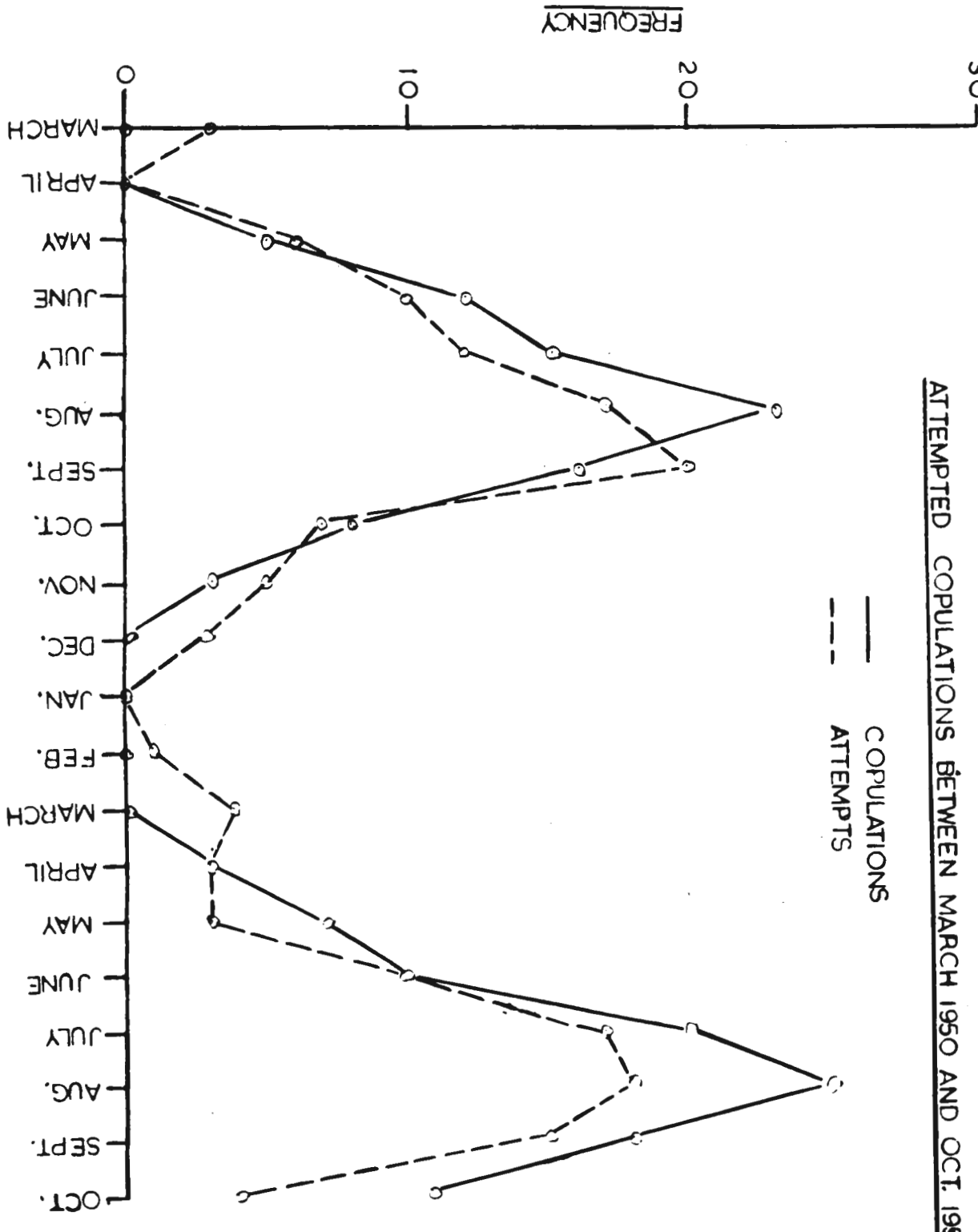
2) An interesting aspect is the possible competition which the beetle encounters in its environment. In the Western Province there are a number of beetles, apart from Stenoscelis, which till recently were considered of primary importance as regards damage to timber. The best known of these are Hylotrupes bajulus, Anobium punctatum, Lyctus brunneus and some Bostrichids. Stenoscelis now appears to be heading the list after Hylotrupes, and the question arises as to whether this is because these competitors are being eliminated thus leaving an open habitat for Stenoscelis, or merely because the regulations regarding compulsory eradication of Hylotrupes infested wood, and strong recommendations to remove all Anobium and Lyctus infested wood as well (which came into force in 1946) have unearthed hitherto unsuspected infestations by Stenoscélis. (The number of reports of Stenoscelis infestation increased from 1946 onwards).

All the available information represents number of reports of Stenoscelis infestation, rather than number of beetles, and thus at this stage it cannot be decided which of the two possibilities mentioned above is the actual correct one.

The study of the preferences of the other important woodborers in the W.P. as compared with Stenoscelis, shows that this beetle has an extremely wide range of attack, as far as type of wood, age of wood, and conditions of wood

62/.....are.....

FIG. 15



FREQUENCY DISTRIBUTION OF COPULATIONS AND ATTEMPTED COPULATIONS BETWEEN MARCH 1950 AND OCT. 1951.

are concerned. In fact it seems to embrace nearly all the preferences of these other beetles. If, as has been suggested as a possibility, these beetles are competitors of Stenoscelis, the wide range of the latter will make for its greater success.

3) It is unfortunate that the oviposited egg of the beetle was never observed, since on this observation depends much of the following work. Important results which are consequently left to conjecture are: a) the exact time of oviposition b) the exact time of hatching of the eggs c) the total length of the larval stage and consequently the total length of the life history of the insect generally. The lack of a description of the life history of a beetle of the same or an allied family, with similar habits, makes even a comparitive guess difficult.

In common with many Curculionids, the eggs of Stenoscelis, when laid, are probably very small, and of indeterminate colour. Moreover they are laid inside the wood and are therefore probably overlooked.

4) As has been pointed out above, the oviposited egg, and consequently the newly hatched larva have never been observed. These larvae are no doubt very small. Larvae were only observed after they had reached a certain size and one consequently has no idea of the number of instars which they have passed through before this size. Therefore the total number of instars is not known, and the author had to start his investigations with larvae that have already passed through some instars.

The habit of the larva of boring in wood makes it extremly difficult to actually observe a series of moults in any individual larva, as has been explained in the text. However, some idea of the number of larval instars was necessary, and the author was forced to resort to a series of indirect methods ofdetermining this number of instars,

63/.....and.....

SUMMARY.

1) Stenoscelis hylastoides is distributed in the coastal areas between the Western Cape Province and Natal, as far as is known, and is considered an important economic wood-boring pest in the Western Cape Province. It shows signs of becoming an even greater problem.

2) It attacks a large variety of types of wood, but prefers the softer varieties.

3) The egg stage as such was not observed, but the egg was seen in the ovary. The female appears to return into the wood after copulation to oviposit.

4) The larval stage has been studied as far as possible, but the hard medium in which it lives, makes it difficult to obtain an accurate picture of the total life history. By three different methods, a life history of about 1½ years is indicated, with about 13 instars.

5) The pupal stage has been closely studied. Its duration was found to be 22.5 days days (Average), and it takes place during the height of the summer.

6) There is no noticeable external difference by which the different sexes could be identified in the adult form.

7) The beetles emerge during the winter months, and copulate towards the end of the winter. It is supposed that the females return to the wood to oviposit during the early Spring.

8) Adults may live up to 14 months. It was found that intermediate temperatures (60 - 70°F) and Relative humidities of about 75% to 90% were the best conditions for the adults.

9) Certain natural enemies are present, and these may be of use in the future control of this beelte.

68/.....LITERATURE...

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